LORENZ BÖHLER

TREATMENT OF FRACTURES

TRANSLATED BY M. E. STEINBERG

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THE TREATMENT OF FRACTURES

BY

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TO MY WIFE AND CO-WORKER

TRANSLATOR'S PREFACE TO THE ENGLISH EDITION

I HAVE observed Primarius Böhler's work at the Vienna Accident Insurance Hospital periodically for the last sixteen months and have also been given the privilege to use his methods personally. The excellent results obtained by Dr. Böhler in the treatment of fractures have inspired me with the wish to render his teaching accessible to the English speaking surgeons.

This book is essentially a record of the author's vast and intensive experience. He has not followed the beaten path but courageously analyzed and criticised some of the orthodox methods in vogue and advanced his own theories and technique. The hundreds of surgeons from various lands, who have visited Dr. Böhler's clinic at the Accident Insurance Hospital of Vienna have been convinced by the rationality of his teachings and impressed with the brilliancy of his results.

At this time, when so much interest is displayed to advance the treatment of fractures and to find more uniform and better methods, this book should meet with a favorable reception. The translator has attempted to convey the original ideas of the author by strictly adhering to the text.

I wish to acknowledge my indebtedness to Dr. Joseph E. Bellas of Marquette, Michigan, for the correction of the manuscript and for proof-reading.

Vienna,
June 1929

M. E. STEINBERG
(Portland, Oregon)

AUTHOR'S PREFACE TO THE GERMAN EDITION

THIS book is an attempt to bring before the Profession my experiences in the course of the last nineteen years based on more than ten thousand fractures, also on the study of about seventy thousand roentgenograms and the dissection of more than three hundred fractures on the post-mortem table, performed chiefly during the War. It also represents the teaching to numerous post graduate students.

I have been engaged in small and large hospitals in the capacity of an assistant or as surgeon in charge. Furthermore I have served as a ship's surgeon and have conducted a general country practice. At the beginning of the War, I was at the front and later, behind the front in a two hundred bed hospital for fractures, organized and directed by myself. After the War, for several years I was engaged in general surgical and orthopaedic practice in a smaller town, without any official connection with a hospital. The above experience has given me the opportunity to observe and to learn the practice of medicine under a variety of conditions.

Since the results following the treatment of fractures have not been satisfactory, I have attempted to search for the causes responsible for the many failures. The latter are in part due to some prevailing anatomical misconceptions and, in part, depend on the lack of organization and the lack of a proper technique. I have endeavored to make the anatomical relations clear by studying the locomotion apparatus on normal cadavers and on those of patients who died in consequence of injuries and fractures, by following up my cases clinically, and also by a systematic analysis of numerous serial roentgenograms.

Theoretical knowledge alone is not of the greatest benefit to the patient, if the practical experience is lacking. I have been repeatedly impressed by the fact that the treatment was suffering from the lack of the necessary materials, or from their improper preparation. For this

reason I have described in detail all the items and materials required for the treatment of various fractures; also the numbers of assistants necessary. The successive steps of the treatment, the position of the patient, the time required and what is to be expected from such treatment, have also been given. The most common errors made are mentioned in connection with the treatment of each fracture.

The success of the treatment in a hospital does not altogether depend on the surgeon's skill, but also on the organization. The latter has therefore received a short sketch also.

The book contains numerous original illustrations, since much more can be learned from the latter than from lengthy descriptions. Most of the diagrams have been drawn by Dr. Mauritz.

I wish to express my gratitude to Hofrat Dr. Hendrych, the director of the Workers' Accident Insurance Organization, for his liberal attitude and generous provisions for the needs of the hospital.

Vienna,
March 1929

LORENZ BÖHLER

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GENERAL PART

GENERAL REMARKS ON THE TREATMENT OF BONE FRACTURES

The most important consideration in the treatment of a patient with a fracture is to save his life, then to save the injured extremity, and finally, if we have succeeded so far, to restore, in the shortest time possible, the full capacity of the function of the affected limb.

Life is threatened chiefly in old people, whom the serious injury suddenly compels to lie in bed, thereby exposing them to the dangers of pneumonia and bed sores. Here it is imperative to make the patient free from pain and to compel him to leave the bed. Life is also threatened in alcoholics and people with serious affections of the circulatory and respiratory organs. We treat the former chiefly by supplying the necessary amount of alcohol, and the latter by cardiac remedies in the manner accepted by present day practice.

A frequent complication, which often endangers the injured extremity and the life of the patient, is the open wound, which creates a communication between the fractured bone and the outside, producing a compound fracture. Here it is most urgent to change the open fracture immediately into a closed one. In this way most infections can be avoided.

FUNDAMENTAL LAWS FOR THE TREATMENT OF BONE FRACTURES

The quickest and best way of making a fractured extremity again capable of function, consists in the proper reduction of the dislocated fragments, in the prevention of atrophy of the muscles and in the avoidance of progressive stiffness of joints. In the treatment of every fracture the following fundamental rules must be adhered to:

(1) The peripheral fragment must always be placed in the direction where the central one points.

(2) Every fracture must be reduced by means of traction and countertraction.

(3) After the reduction the fragments must be kept continuously in the right position until firm union takes place.

These three fundamental principles are always sound and must never be neglected. There are different ways of applying these rules and the results of the treatment are nearly always favorable, if we adhere strictly to their performance.

The *first fundamental law* sounds exceedingly simple but it is frequently not adhered to, because the exact position of the

Fig. 1

Fig. 2

Fig. 1. Adduction fracture of the humerus through the surgical neck. Between both fragments there is an open angle facing the mid-line and also posteriorly; there is, therefore, a displacement of the axis in two planes. The distal fragment is displaced laterally and inverted. There is also a shortening.

Fig. 2. By abducting the whole arm, the fragments are brought into a straight axial alignment in the frontal plane. The lateral displacement, the rotation, and the shortening are still present. This corresponds exactly to the position of the arm on Middledorpff's triangle (Fig. 103).

Fig. 3

Fig. 4

Fig. 3. By rotating the abducted arm till it reaches the horizontal plane, the displacement of both fragments by rotation also disappears.

Fig. 4. The shortening disappears after a longitudinal pull is applied.

fragments is either not known at all, or only insufficiently understood, and because the various forces, which have produced the dislocation of

the fragments and which mantain it, are frequently not taken into consideration. The original dislocation of the fragments is produced by the force fracturing the bone. It is, however, by the muscular action, that the dislocations are continued and assume their typical forms. The law of gravity also plays an important rôle here. The longitudinal displacement is naturally a shortening, which is caused by the muscles running along over both fragments. Every shortening with a longitudinal displacement brings about a lateral dislocation; this is easily understood, since the fragments can never glide one along the other unless a shortening took place. The various rotations and the displacements in the axis are produced only in small part by the muscles passing over the fragments. These deformities are in a greater measure due to the attachment of the muscles to the shorter fragment nearer the joint.

Fig. 5
The lateral displacement disappears after pressure is applied on the peripheral fragment from below.

The older methods, and especially those of Bardenheuer, provided special traction for each displacement, so that, besides the longitudinal traction, there is also lateral and rotatory extension. Such treatment is based altogether on purely mechanical principles and disregards the laws of muscle physiology. Zuppinger first pointed out in a systematic way, that when the joint is flexed, the extensors and flexors are equally relaxed and that the reduction of the longitudinal dislocation is accomplished with little force. In uni-axial joints it is possible by simple bending to bring the peripheral fragment in the direction of the central one. The case is much more intricate where the joints move in various planes. The fragment which is near the joint cannot be directly influenced, particularly when it is very short, and it is therefore very important to know exactly its anatomical position. The position of this fragment is quite different than under normal conditions, because only a part of the origin or insertion of the muscles are attached to it. These muscles exert a pull in one direction only and are not counterbalanced as in the intact extremity. On account of the reflex spasm in the muscles, the broken fragment, together with its neighboring joint, becomes one unit. For these reasons it is impossible to bring the distal fragment of a fractured bone near a joint, in the direction of the central one without engaging the neighboring joint also, and without putting it in a definite and fixed position, so as to point in the direction of the central fragment.

As an illustration, of what has been mentioned, we shall make a few remarks about the fractures of the upper and lower ends of the

humerus. Zuppinger and Christen pointed out that in fractures of the upper end of the humerus the central fragment is abducted 90° and also outwardly rotated 90° and that therefore one must bring the whole arm into this position (Figs. 1–5). I would like to add, that we must also bring the arm in the horizontal plane and anteriorly in such position, that it makes an angle of 30° or 40°.

In the supra-condylar fractures of the humerus, the peripheral end is usually found to assume a flexion and a varus position. In this case we can obtain a good position, when we bring, not only the peripheral segment, but the whole peripheral part of the limb, which forms a unit, in the position in which the central fragment points. The conditions here appear somewhat intricate, since the joint next to the fracture really consists of the humero-ulnar, humero-radial and the radio-ulnar articulations. According to the rules prescribed in the text books, the forearm must be fixed in supination in the treatment of such fractures. On account of the haematoma and other factors, which bring about the irritation of the muscles, the pronators, which are stretched on account of the extreme supination of the forearm, are also in a state of spasm. These muscles, however, are not able to pronate the forearm, which is fixed in supination, so they pull on the distal fractured piece and bring it into a varus position. This varus position can be easily reduced by pronating the forearm and thus relaxing the whole group of the pronator muscles (Figs. 6, 7). Because the pronators are also the flexors of the elbow joint, their relaxation brings about the reduction of the flexion deformity of the lower fragment. In order, therefore, to reduce this type of fracture, we must flex the elbow at right angles, pronate markedly the forearm and exert longitudinal traction. In this way we always succeed in reducing all the displacements. By this method of treatment we have not only relaxed the muscles, correctly reduced the fragments and given the joint a mid-position, but we have also freed the blood vessels and nerves from their dangerous compression in the neighborhood of the fracture. Ischaemic muscular contractures are most frequently observed after this form of fracture. The plaster of Paris cast is usually blamed, but the position of the fragments and the strangulation of the vessels, especially when the elbow is in extreme flexion, are to be blamed for such injurious sequelae. An energetic pull on the forearm in a pronation will free the vessels from their strangulation and enable us to feel the radial pulse again (Figs. 8, 9). Paralysis of the radial nerve is also seen in these fractures, because the nerve passes over the sharp upper corner of the lower fragment and is here compressed (Figs. 6, 7). This injury can also be prevented by the pronation of the forearm. By the proper adjustment of the peripheral part of the extremity, we can also demonstrate in a clear manner the pathological entity and mechanism of the fracture, as Zuppinger already has shown.

In every fracture we have to deal, not only with a separation of continuity of the bone, but, also at the same time with a more or less

serious injury to the muscles and with an extravasation of blood from the lacerated vessels. The extremity has lost its inner support and the muscles their physiological balance. This, together with the blood effusion, exerts injurious influences on the surrounding tissues and seriously interferes with the circulation of blood and lymph.

Fig. 6 Fig. 7 Fig. 8 Fig. 9

Fig. 6. A faulty position of a fracture at the lower end of the humerus (supra-condylar) on an elbow-splint with the forearm in supination. On account of the stretched pronatores which are also flexors, the lower fragment is pulled into an adducted position (varus) and is also flexed. The pronator teres is overstretched. In addition to the above, it is seen that the radial nerve is riding over the sharp, upper edge of the lower fragment, and is in danger of being injured.

Fig. 7. The correct position of a fracture of the lower end of the humerus with the forearm in a relaxed position, that is, in pronation. On account of this position of the forearm, the pronator muscles are relaxed and the adduction and flexion deformities of the lower fragment disappear; the radial nerve is not being compressed or pinched by the sharp end of the lower fragment.

Fig. 8. If there is a pronounced displacement of the fragments, the blood-vessels are being compressed between the lower, sharp edge of the upper fragment and the ulna. An ischaemic contracture of the muscles is produced.

Fig. 9. After the forearm is pronated and a longitudinal pull applied, the displacements disappear, and the blood-vessels are again free.

It is not without interest to point out, that this entity was already known to our predecessors, as ascertained from the *Merseburg Magic Formulae,* the oldest German work written: "Be it a bone luxation, be it a blood luxation, be it a luxation of the extremities, leg to leg, blood to blood, extremity to extremity, as if they were glued together." It was reserved for the medical men to separate this entity and arbitrarily

to treat the bones, the muscles or the joints separately, not as a whole inseparable unit.

The *second fundamental rule,* which consists of the reduction of the displaced fragments by means of extension and counter-extension, is generally known. Such pull can be momentarily exerted either by the hands or by the screw traction apparatus, but for the continuous effect, we need the weight-extension. It is important to add, that extension and counter-extension, as for instance in the correction of typical fractures of the radius, should be discontinued only when the cast has hardened. Longitudinal traction is necessary for the correction of every fracture with displacement. Only in this manner can the shortening be reduced. The angular deformities always disappear when the distal fragment is placed in the direction towards which the proximal one points. The correction of the lateral displacement is only possible after the shortening has been reduced. After the shortening disappears, the lateral displacement disappears either of its own accord or by means of lateral pressure. The deformities which are brought about by the rotation of the fragments, also disappear after the distal fragment is placed in the same direction toward which the proximal points. In these particular displacements, there are many wrong methods advocated. The result of this is, that the lateral and rotatory tractions become mostly superfluous, if one takes into consideration the various conditions of muscular action.

As an example of this, we shall again mention the fractures of the upper end of the humerus. In this type of fractures, all the four displacements are present: First there is the displacement in the axis, then the rotation, and then also the lateral displacement and the shortening. The axial displacement and the rotation can be corrected by placing the distal part of the upper extremity in the correct plane, while the lateral displacement can only be reduced after the shortening has disappeared under powerful traction. It is quite evident, that any lateral pull is of no avail unless the shortening has been reduced. In fractures of the shaft, lateral displacement will disappear spontaneously, because the muscles which surround both fragments, like an elastic tunic, press them together into the correct position, after the shortening is reduced.

The *third fundamental rule* consists in the continuous immobilization of the properly reduced fragments, until firm union has taken place. This, however, is most frequently not adhered to, because many surgeons fear the stiffening of the joints in consequence of a long continued fixation. One is only able to follow this rule intelligently, if one knows when the fracture is sufficiently solid. It seems, however, that the opinions regarding this matter are faulty.

In general the time allowed for fixation is too short. For the fracture of the forearm, only three to four weeks of fixation are advised. According to *my* experience, transverse fractures in the middle of the radius rarely heal before eight weeks, and often a much longer

time is required. Transverse fractures in the middle third of the tibia, are never solid in six weeks, but require ten weeks and frequently more. How little these conditions are known, was recently proved to me by the case of a young physician. He suffered an ordinary torsion fracture of the leg and was given a plaster of Paris cast, which was removed after six weeks. When he was unable to walk without crutches after ten weeks, he applied to me, because he had been told that my patients could walk without a cane two or three days after the fracture. His leg was much swollen. There was also a shortening, a varus position and convex deformity backwards. The callus was still soft and therefore not able to withstand weight-bearing. It was possible to reduce all the deformities without any anaesthesia. The usual non-padded plaster cast was applied, and the patient was able to walk immediately and without the use of a cane. Six weeks later and therefore sixteen weeks after the accident, the fracture was sufficiently solid, and able to withstand weight-bearing. This physician related that he has treated many such bone fractures and that all of them had been fixed for six weeks only. His patients, however, had to use crutches for a long time; for me this was proof that the fractures thus treated, had not been firmly united, after six weeks.

THE FUNCTIONAL TREATMENT

Function means the capacity to use. Functional treatment, therefore, demands the ability to use the limb as soon as possible. The dreaded consequences of every fracture are shortening and other deformities, also the stiffness of joints, atrophy of muscles and swellings of long duration. The shortening, the angular and rotation deformities, can be avoided if we strictly adhere to the rules expounded by holding the properly reduced fragments in a good position until firm union takes place.

While the reduction of some recent fractures is relatively easy, it is often difficult to keep them continuously in the proper position. A good result cannot be obtained, if we use one method of treatment such as plaster cast, a splint or extension or only massage, passive or active movements in all the fractures. The kind and the location of the fracture, the constitution and the age of the injured person, as well as the facilities for treatment, place before the physician quite different tasks. Good results can be obtained with every method of treatment, provided that it is carried out in the right place, in the right way and at the proper time; none of the methods, therefore, should be absolutely declined or discarded.

By functional treatment we understand the complete uninterrupted fixation of the fragments in good position with the simultaneous active movements of all the joints, or as many as possible, and with the avoidance of any pain. The fulfillment of these demands depends on the technique of bandaging and the type of immobilization.

Every fracture is concomitant with a serious injury to the whole process of and structures concerned in locomotion; it is therefore important, to consider these injuries and to treat them accordingly. Bones, muscles, joints, vessels and nerves and also the skin should be considered in the same manner, and one organ or tissue must not be neglected at the expense of the other.

In many fractures, as in those of the femur, the functional treatment can best be accomplished by the use of weight-extension, while in others the accused plaster of Paris cast is indispensable. The latter has often been rejected, because the use of plaster cast has been associated with the atrophy of muscles and bones, and the stiffening of joints in the minds of many surgeons. This idea is historically founded on the fact, that after the introduction of the plaster of Paris by Mathysen in 1852, all fractures and all diseases of the bones and joints, were indiscriminately treated by the application of enormous plaster casts, which often enclosed the whole extremity. In the typical fractures of the radius, the bandage extended from the finger tips to the shoulder. These extensive plaster casts immobilized all the joints of the extremity and, because of the weight, often condemned the afflicted to bed for weeks and months. Everything was expected from the plaster cast and therefore, insufficient stress was laid upon the proper reduction. The long continued inactivity of the whole injured extremity and often of the whole body, and, at the same time, the improper reduction, were the causes of serious and lasting disturbances.

Later on, however, the observation was made, that shepherds treated fractures by reduction, using only tape for fixation and in addition massage and friction. This method of treatment gave better results than those obtained by physicians, who used plaster of Paris casts. All the blame for the unsuccessful results was put on the plaster of Paris casts and the treatment by massage and passive movements was taken up with as much enthusiasm and partiality as the relegated plaster. Lucas-Champonière was the chief advocate of this method of treatment. He frequently omitted the reduction of the displaced fragments and treated the joints from the very first day by passive movements, to prevent stiffness, and massage, to prevent muscular atrophy.

Whole systems were founded upon this method of treatment and many laws relating to insurance against accidents are crowded with its slogans based on these principles. Various statistics were resorted to in order to give support to these ideas. Long columns of figures were used to prove that the number of the definitely cured cases were greater, if they were submitted to early treatment by massage and movement. There is some truth in these figures but their cause can be explained in the following manner. In the past in Germany, as a result of local laws, the patient did not come under treatment with the insurance companies until the end of the fourteenth week. After this period of time most of the fractures are healed, and only the most serious or

poorly reduced fractures in old people are left for treatment. Most of the patients had been cured a long time ago, although they were not submitted to massage. This particularly applies to fractures of the ankle joint, 70% of which occur without displacement and 30% show more or less displacement. If we begin with massage and movements four weeks after the accident, most of the cases, which originally showed no dislocation, are capable of movement, and work after a few weeks. From these facts and sophistic reasonings the conclusion was drawn, that all these cases had been cured by massage and that all the other cases, even those with serious dislocations should also have been submitted to treatment by massage and movements from the first days. The fact that the serious cases nevertheless did not heal, was ascribed to the lack of recuperative ability of the patient and his desire to claim sick pay for disability (although some of them endured the torment of this new art of healing with true heroism). In these negative cases, the physicians encouraged themselves and assured their patients that the failure was due to a general predisposition for joint stiffness on the part of the patient.

If the fragments are dislocated, and at the same time the joints partially or entirely luxated, it is important first of all, to bring about an exact reduction and then use a proper support to immobilize the bony fragments until union takes place. Whether we use wooden or metal splints, a plaster cast or an extension dressing or the expensive sheath apparatus, is quite irrelevant. It is only important that the method used for the immobilization be reliable and durable, and that it be not removed too soon. The best, the most convenient, and inexpensive material for this use, is plaster of Paris, which can be used in many of the various fractures. Without the proper support for immobilization the fractured limb remains painful. Not only the movements of the injured extremity or joint cause pain, but also the movements of distant joints. The injured extremity must therefore be kept at absolute rest. Blood circulation in this region is greatly retarded since, according to Bier, an active muscle draws arterial blood in and propels the venous blood when it contracts. When it remains inactive for a long time, the blood supply decreases and the venous blood stagnates, producing the retention of transudates in the extremity. The muscle substance becomes atrophic and the amount of lime salts in the bones decreases.

If an inflammation exists in a joint, or in part of an extremity, an increased blood supply takes place. Most of the blood, however, flows to the injured part but is withheld from the muscles. In inflammations the limb must also be kept immobilized and therefore, on account of the inactivity, the lack of blood supply will also help to bring about the atrophy of muscles and bone. It is also possible, that the inflammation brings about by-products which are apt to act injuriously on the muscles and bones. As soon as the bones have lost a part of their lime salts, the capacity for weight-bearing is reduced and the limb is exposed to

pain. If, in these cases, a support is used to immobilize the fragments, the pain disappears, and the extremity can be passively and actively used. Appetite and sleep return and the patient does not consider himself a sick man. The muscles again begin to work and draw in blood. Here it must be especially emphasized, that muscles can work and contract, without their points of origin and insertion approaching each other.

We are able, for instance, to contract the quadriceps powerfully and let it again relax, when the knee joint is extended. Atrophy in the joint cartilage does not take place in spite of many months of immobilization (Risak).

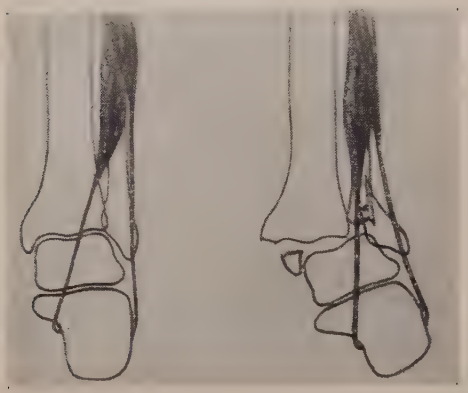


Fig. 10

Left side: A frontal section through the upper and lower ankle-joints with a diagrammatic representation of the pronatores and supinatores.

Right side: A frontal section through the upper and lower ankle-joints with a fracture of both malleoli and a lateral subluxation. On account of the oblique position of the lower surface of the tibia, the astragalus slips to the lateral side and is also drawn laterally by the pull of the pronatores, producing a valgus deformity. The supinatores do not exert a counter pull to correct the lateral displacement, but on the other hand give support to the pronatores, pulling lateralwards because they have now assumed a straight course.

As an illustration of our previous discussion we shall consider a fracture of the ankle joint with a dislocation. If we apply a non-padded cast after the displacements have been correctly reduced and the fragments kept in good position, the patient is usually able to walk without a cane and is completely free of pain. He is now capable of using his injured extremity and the whole body again and that is what we understand by "function."

All the muscles which are not immobilized, are active and therefore do not become atrophic. Only the tibialis anticus and posticus and the peroneus longus and brevis are immobilized. Nevertheless they are at work when the patient uses the extremity. If he walks, he improves the circulation in the whole extremity and naturally also, of the whole body. He is not ill, only wearing a cast on his extremity, and is otherwise quite healthy. Since he is not bed-ridden, he is also not subject to any heart or lung complications. The ability to walk has especially a good influence on the patient's mental attitude. If we are able to prevent a feeling of illness in the injured who are insured against accident, then it is also possible to eliminate most of the compensation neurosis. If we remove the cast after six or eight weeks in a patient who has diligently exercised, we find that the ankle-joint is freely movable, always in a half range of its motion and in case of young individuals, in the whole of its range. The skin is

quite normal, the atrophy of the muscles is slight and the X-ray picture shows no atrophy of the bones.

If massage is instituted as the method of treatment, and the cast removed, the foot at once slips out of its place, since on account of the fracture, the muscles have lost their physiological balance. Normally, the supinatores and pronatores are in a state of equilibrium but, after a fracture has occurred with displacement, the supinatores, which are also adductors, assume, under the changed conditions, a pronating and abducting function. Above all the Achilles tendon pulls the foot into a valgus and abducted position (Fig. 10). Passive movements cause severe pain and the patient is unable to walk because the extremity is not completely immobilized. Pronounced atrophy of the muscles and bones results from this form of treatment.

The healing takes place in an incorrect position and the movements of the joints are limited. On account of weight-bearing on joint surfaces which are incorrectly apposed, arthritic changes take place and the joint stiffness progressively increases from year to year. Therefore we have established the following principle, which at first sight, sounds paradoxical: "*If we reduce exactly a broken joint and continuously hold it in a good position until union takes place, and at the same time, allow the use of the fractured extremity, we obtain a movable joint, while on the other hand, if we apply massage and passive movements in the first days after the fracture, the joint becomes stiff.*"

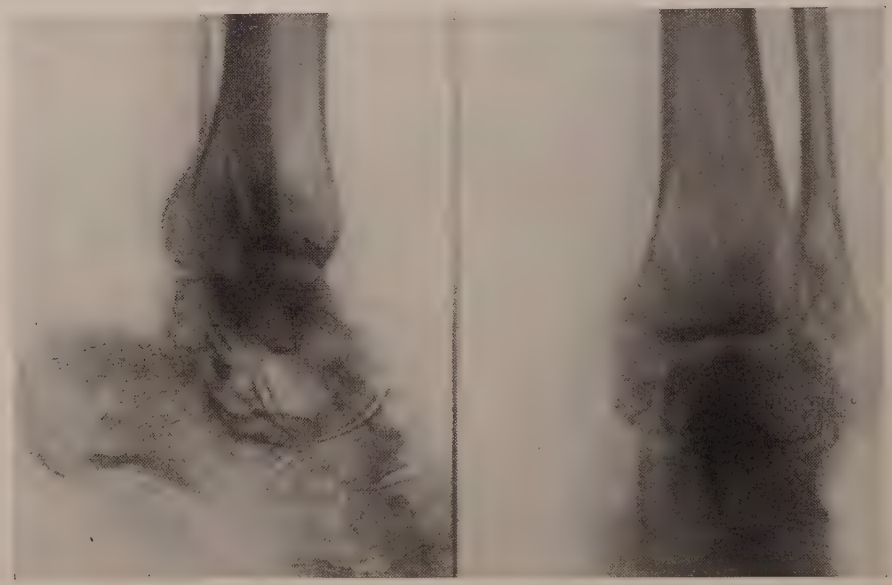
Active movements are, in every respect, preferred to passive movements. The patient can always perform active movements, but passive movements can usually only be practised for one to two quarter-hour periods daily, while during the other ninety four quarter-hour periods, the muscles and joints and the whole individual are inactive, the patient is ill and he suffers pain.

Even if bone atrophy has already taken place and pain is still present, it is still possible to redeem the patient's limb, if we use a non-padded plaster cast. The truth of this statement has been proved in many cases.

A patient, forty years old, suffered a contusion of his right foot. The foot was very much swollen and was treated by application of moist dressings, by massage and by passive movements. We saw the patient three months after the injury for the first time. The foot was very much swollen, a little discolored and very painful under weight-bearing. The X-ray picture showed that there were no fractures, but an extensive and evenly distributed bone atrophy was present. The picture gave the impression of a case of joint tuberculosis. The foot was elevated until the swelling disappeared and the patient then given a non-padded cast. After a few days he was able to use his extremity and he was also free from pain. The cast was removed after four weeks, the swelling disappeared and the skin was normal. The atrophy of the bones showed a considerable improvement; then we applied the

usual zinc-gelatine dressing. After four weeks more, the patient was again able to work. He was free from pain, he had powerful muscles and free joints again.

Another illustration is that of a lady who suffered a fracture of both malleoli. She was operated on at some other hospital, where the inner malleolus was fastened with a screw. On account of secretion which appeared three weeks after the operation, the screw was removed. A few days after this operation, the ankle-joint became very much swollen. She consulted another physician, who recommended massage and passive

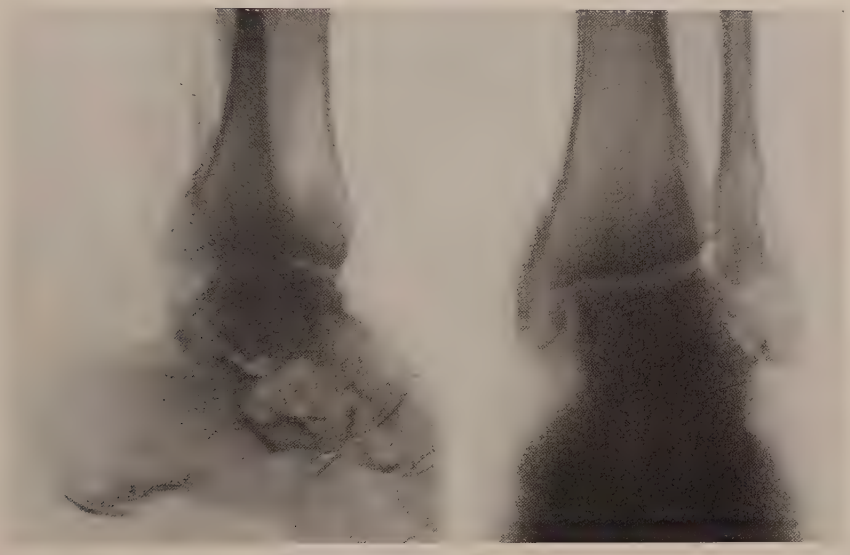


Figs. 11, 12
Extensive, spotted atrophy of the tarsal bones. Destruction of the upper ankle-joint.

movements for the treatment of the swelling. After the first day of this treatment, the patient had chills and then a high fever, which lasted for weeks. The operation wound became infected and took three months to close. She left her bed four months after the injury. We saw her for the first time five months after the accident. She carried her foot in an orthopaedic appliance and could walk only by the aid of crutches. The foot was very much swollen and in a drop-foot position. The X-ray picture showed destruction of the joint surfaces in the upper ankle-joint and also an extensive atrophy of the bones of the whole foot (Figs. 11, 12). She stated, that in the last two months she was again treated by daily massage and passive movements. The next morning, after the swelling had subsided, we corrected the position of the drop-foot and applied a non-padded cast. In a few days the patient was free from pain, was able to walk without a cane and had, therefore,

once more the full use of her extremity and of the whole body. The cast was removed ten weeks after its application. The atrophy of the bones of the foot had considerably improved and the patient was able to walk without pain and without the use of a splint or a cane (Figs. 13, 14). The after treatment consisted in the application of the zinc-gelatine dressing.

Massage and passive movements are also responsible for a large part of pseudarthrosis, especially for that of the scaphoid of the hand. The early institution of passive movement and massage prevents a firm



Figs. 13, 14

Control pictures of Figs. 11 and 12. After ten weeks in a non-padded walking cast the spotted atrophy of the tarsal bones has almost completely disappeared.

bony union in the fractured scaphoid, and often brings about the atrophy of the carpal bones and later on, also severe changes in their articular surfaces. That massage and passive movements are the causative factors in the production of the pseudarthrosis and bone atrophy, is proven by our statistics. In sixty cases of recent fractures of the scaphoid bone, we have always obtained a bony union with no bony atrophy after complete immobilization by means of the non-padded dorsal plaster of Paris splint, which remained on for six weeks. A most interesting fact is that we obtained good results also in the old cases which came to us with cavity formations in the scaphoid and atrophy of the other carpal bones. We immobilized the carpal bones for four to six months, and we observed the disappearance of the bone atrophy and of the cavity formation, and the complete bony union of the fracture.

We also observed in many inflammatory cases, that the immobilization by means of the plaster of Paris cast, brings rest and the disappearance of the atrophy. If we use massage and passive movements the inflammation flares up and the fistulae, which are present, are often turned into extensive phlegmons. We shaw thousands of these cases during the War. On account of this treatment, many lost their extremities and some also their lives.

After these experiences, I must say that I consider *massage and passive movements in all recent injuries and diseases as being most harmful.*

In poorly healed fractures and in inflammations which have subsided, and in the presence of swellings, the use of massage gives good results. Physio- and mechano-therapy will always have a prominent place in the practice of medicine. It must, however, be applied in the correct place and at the correct time and should not be considered as a "cure-all."

Massage and passive movements not only cause pain but also disturb the rest, so necessary for the process of healing.

In all injuries and diseases, we find the same symptom-complex. Pains arise either spontaneously or as a result of attempts at movements. The pains disturb, not only the physical well-being, but also the mental attitude of the patient. Since the extremity is painful, it is not used, and therefore brings about the atrophy of bones and muscles. If we, however, give the injured or inflamed extremity a firm support, either in the form of a non-padded light plaster cast, or an extension dressing, the conditions become quite different. The pains disappear, the extremity can be used, and the individual is really no longer a sick man. The atrophy of bones and muscles, previously referred to, does not take place or, if it has already appeared, it soon subsides.

THE INFLUENCE OF THE AGE AND CONSTITUTION OF THE PATIENT ON THE HEALING PROCESS OF FRACTURES

The healing process of fractures is quicker in children and in juveniles in the period of growth, than in the old. The healing is considerably retarded when the bones have already become porotic. This is especially so in fractures of the neck of the femur in old people.

The return of the ability of the joint to move also depends primarily on the patient's age. One never sees a long-lasting joint stiffness in children, even if the immobilization by plaster cast lasts many months, provided, however, that the fracture has been properly reduced. In older people an immobilization of two to three weeks, especially, if the joint is kept in an unphysiological position, is sufficient to produce a lasting disturbance.

Swollen extremities are rarely seen in young patients with a normal circulation. In older patients, and especially in those with a varicose vein symptom-complex, and in those of a short stout habitus with

ruddy complexion, the symptoms, especially the oedema, are troublesome and persistent.

The functional treatment of Lucas-Championnière has endured so long, because all the fractures, irrespective of the degree or of the age, were considered in the same manner. It was considered that all the joint fractures were in danger of becoming stiff or incapable, even if no dislocation had occurred. As a matter of fact, the situation is quite different, since joint fractures, without displacement of the bone fragments, cause negligible disturbances of function or none at all. Such fractures give good results, irrespective of whether they are treated with or without bandage, with or without massage and with or without passive movements. The difference lies only in the length of time required for the healing and in the degree of pain which the patient has to bear, and this depends upon the method of treatment. In cases where the fragments are displaced and the joint is partially or totally dislocated, we shall attain a good result only when we are able to reduce correctly the fragments and the joint and to keep them in this position until healing.

It appears to me, that the good results mentioned in the various publications, which defend the treatment by active and passive movements, are chiefly in young patients. Only statistics of old people, and those with the constitutional habitus previously described, would give evidence of the efficacy of the treatment. On the contrary, it would be very interesting indeed if a stiff joint were reported as the result of a plaster cast in young individuals, because a free joint is the normal result after cast treatment in these patients.

THE METHODS OF ANALGESIA

Every recent fracture is painful unless it happens in individuals, who are afflicted by tabes or syringo-myelia or who are in a state of acute alcoholism. The pain is aggravated by the least movement. The patient contracts his muscles reflexly in order to avoid the pain and therefore aggravates the displacement. The muscular spasm is particularly great and often insurmountable, when the extremity is being pulled in the attempt at reduction.

The pain can be alleviated either by general anaesthesia or by local or regional analgesia. In all recent fractures we use local analgesia, and only in isolated cases regional anaesthesia but no longer general anaesthesia. We can recommend this form of analgesia since we have used it in more than three thousand cases without the slightest injury, whether in form of an infection of the haematoma or an intoxication.

The method of local analgesia is extremely simple in recent fractures. In the usual manner of infiltration anaesthesia, such as in operating for an inguinal hernia, we must infiltrate all the tissues. In a recent fracture the circumstances are quite different, since a haematoma is present which penetrates all the tissues in the vicinity of the broken fragments. It is

sufficient to introduce the needle down to the broken fragments and to inject the solution, which is at once diffused in the haematoma. The anaesthesia takes place immediately and as a result, the muscular relaxation. The greatest obstacle to the reduction of the fracture is now eliminated.

The technique of local anaesthesia. The following items are needed:

(1) 2 sterile 10 cc. record syringes.
(2) 2 short and 2 long and slender needles.
(3) 2 sterile tissue forceps.
(4) 30–50 cc. of a 2% novocaine solution (in place of this tutocain or any other cocaine derivative may be used).
(5) Tincture of iodine.
(6) A few sterile swabs.

It goes without saying, that everything must be sterile; the needles should be applied only by means of the tissue forceps and not be touched with the fingers; in order not to be delayed, we should always have two syringes ready. After we determine the site of the fracture, judging by tender point, we paint the skin with tincture of iodine and then introduce the needle until the bone is felt. We now inject 4 to 5 cc. of the solution and take off the syringe. If a red-colored solution escapes from the needle, we know that we are in the haematoma, and now we can inject 15 to 20 cc. of the solution with the same needle. If the solution comes out clear, we must try again, until the proper place is found.

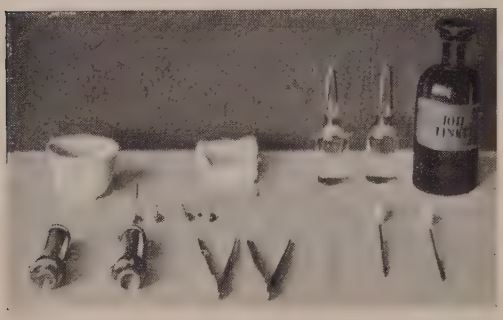


Fig. 15
Small table used for the local anaesthesia outfit. Two syringes, each 10 cc.; two short needles and two long needles; two applicators for painting with tincture of iodine; tincture of iodine; two ampules, each containing 20 cc. of a 2% novocaine solution; sterile sponges and a beaker for the solution.

If the bone is broken in two places or if more than one bone is broken, we inject the solution into the site of every fracture. We can use 50 to 60 cc. of a 2% novocaine solution without any danger. In those fractures, where the displacement is minimal and where the haematoma is small, we are occasionally forced to inject the whole circumference of the bone.

After the injection we should never lose sight of the patient; because when the pains completely disappear, the patient is liable to make an untoward movement and receive a serious new injury such as, for instance, to lacerate the skin with the sharp end of a bone fragment. I remember one case of a usual Colles' fracture which I injected with the patient in a sitting position. After I requested that he should get on the operating table, he made an attempt to support himself on the broken hand, which was now free from pain. Since this observation,

I inject the local anaesthetic only when the patient is in a lying position. For the same reason no patient should be made free from pain during transport by the injection of a local anaesthetic, unless he is accompanied by a physician who understands the possible dangers.

If we only use $^1/_2\%$ novocaine, a few minutes elapse before it takes effect. During this time, if the patient is not watched, he is liable to move and injure himself. We therefore limit ourselves to the use of a 2% novocaine solution only.

All the advantages of local anaesthesia as compared with those of general cannot be enumerated here. We can only emphasize the following facts. We are able to do away with the severe general disturbances which follow general anaesthesia. We can dispense with an anaesthetist, which is especially of great importance for the physician who works alone. The patient can go to the X-Ray room alone, and we can correct the deformity several times if we do not succeed, under the influence of the same anaesthesia, which lasts from 2 to 3 hours. In particularly difficult cases we can repeat the injection of the anaesthetic solution. The relaxation of the muscles is much more pronounced than in cases where a short and rapid general anaesthesia is used.

Individuals with fractured arms can go home unassisted. The danger of injecting the solution into large blood vessels is hardly possible, if one takes the necessary care to avoid them and if one is familiar with the art of local anaesthesia.

Since in fractures with larger haematomas, only a single puncture is necessary, we were often able to use this form of anaesthesia for children also. In compound fractures, the injection between the fragments should not be done through the soiled wound, but through the neighboring healthy skin.

In dislocations, the method of local anaesthesia offers more difficulty inasmuch as, especially in the shoulder and in the hip, the injection in the joint alone is not sufficient; we must also inject the dislocated parts of the joint which are found lying against the muscles.

If the fracture is a few days old and the haematoma is in the process of organization, it is impossible to inject directly into the haematoma with success; in such cases we inject the whole circumference of the bone.—In fractures which are over two weeks old, it is better to use anaesthesia of the brachial plexus for the arm (Kulenkampff), and spinal anaesthesia for the lower extremity.

The anaesthesia of the brachial plexus is performed in the following manner: The patient either lies on the table or sits up, with his head turned slightly to the unaffected side. The pulsating subclavian artery is now located in the supraclavicular fossa and displaced medialwards; immediately lateral to the artery lies the plexus. A mark is now made in the skin over the clavicle with the finger-nail and the area is painted with tincture of iodine. The patient is directed to say "now" immediately, if he feels a sensation similar to an electric shock in his arm

or in his fingers after the needle has been introduced. The needle which should only be 4–5 cm. long, is introduced obliquely towards the midline. If there is a bony resistance, it is the first rib which indicates that we are behind the plexus. In this case we must pull the needle slightly forwards and make new attempts to find the plexus either medially or laterally. In thin individuals the plexus is found 1 or 2 cm. under the skin. If the nerves of the plexus have been found, and if there is no blood coming out of the needle, we inject 25 cc. of a 2% novocaine solution. The motor and sensory paralysis sometimes takes place at once and sometimes only after 10 to 15 minutes. It usually lasts from 1 to 3 hours. Occasionally the motor function remains unaffected and only the sensory function is paralyzed. In the first 10 minutes however, it may happen that only the motor function is paralyzed and that the sensation for pain is present.

In one of our series of 120 brachial plexus anaesthesias we have once punctured the subclavian artery and produced a haemathorax. In four cases we saw complete paralysis of the whole arm, which only recovered after one or two months. These were long-lasting operations for pseudarthrosis and paralysis, where tourniquets were used. In the last hundred cases, in which we did not use a tourniquet, we did not experience even the slightest harmful after-effect.

We employ *spinal anaesthesia* especially in difficult fractures and dislocations of the pelvis with rupture of the bladder and the urethra. These injuries are frequently due to a crushing force; the thorax and the lungs are frequently also involved. It is evident that we should avoid general anaesthesia in such cases.

The following items are needed for spinal anaesthesia:

(1) 2 sterile record syringes of about 10 cm. capacity.
(2) 2 lumbar needles.
(3) Several short hypodermic needles.
(4) 20 cc. of a 1% *freshly* prepared novocaine solution.
(5) 2 sterile tissue forceps.
(6) Tincture of iodine.
(7) A graduated sterile test tube.
(8) A few sterile sponges and adhesive plaster.

The patient is either sitting or lying. An interspace between any two spinal processes of two adjacent lumbar vertebrae is chosen and marked with the finger-nail, and the skin painted with tincture of iodine. About 4 or 5 cc. of a 2% novocaine solution is injected into the skin and the spinal puncture needle introduced until spinal fluid appears in the needle. 8 cc. of the spinal fluid is collected in the test tube and the same amount of a 1% novocaine solution is slowly injected through the needle. Now the spinal fluid needle is withdrawn and the skin over the puncture covered with a sterile sponge and fastened by means of adhesive plaster. The patient is now placed on his back.

Since we have been taking out as much fluid as we introduce, we no longer notice the violent headaches, vomiting and other symptoms, which often follow a spinal puncture. If, in rare cases, a headache does occur, it usually disappears very quickly after an intravenous injection of 10 cc. of a 10% sterile salt solution.

PSEUDARTHROSIS AND DELAYED CALLUS FORMATION

Pseudarthrosis is the failure of the fractured bones to heal by bony union. The occurrence of this unpleasant complication, according to the statistics by von Bruns, is ½% in fractures of the shaft; according to Scudder occurs in 2% to 3% of cases, and according to Hey-Groves in 4% to 5% of cases. In considering the origin of pseudarthrosis, we must sharply differentiate those which occur in the shaft, those in the intra-articular fractures and also those in the fractures of the apophysis. General and local causes are thought to be responsible for the origin of this complication. Such diseases, however, as tuberculosis, lues, osteomalacia and rickets only delay the callus formation, but do not prevent its formation. Strange to say, however, the pseudarthrosis after fractures of the shaft are chiefly found in powerful and healthy individuals and disproportionately more common in men than in women.

Local disturbances at the seat of the fracture are usually found. We are not, however, concerned with such local diseases, as gumma, carcinoma, sarcoma, osteomyelitis, etc. but only with local disturbances which occur in healthy bone. The cause of non-union may be due to poor reduction of the fragment, and to the soft parts being interposed between the fragments. The most common cause, however, is insufficient and inadequate treatment. In this connection short or interrupted immobilization of the fractured bones is the cause responsible for the occurrence of pseudarthrosis in certain kind of fractures.

The time necessary for firm union does not only depend on the size of the bone, but is also in close relation to the particular bone involved, and depends also on the type of the fracture, the place, the mechanism of the injury, the age and the general condition of the patient.

The callus is formed from the bone marrow, from the broken off splinters, from the periosteum, from the muscles attached to the bone and also from the haematoma which is mixed with the fat of the bone marrow. The younger the individual, the better is the supply of blood to the broken fragments, and consequently the quicker the bone formation. Extensive detachment of the periosteum produces a large subperiostial callus. Transverse fractures, in the lower third of the tibia, and in the middle third of the radius, produce only a very slow-growing callus. For firm union to take place in the fractures of the tibia, we often need 10 to 20 weeks, while in those of the radius, from 6 to 12 weeks. The cause for such delayed growth is based on the fact that the bone marrow

in these fractures is only opened in a small area, that the periosteum is torn transversely and is therefore not detached from the bone.

The anterior and medial surfaces of the tibia are not covered by muscles and the blood supply in this area is poor. Ulcers in this region are therefore very common. By studying the callus formation in fractures in the lower third of the tibia by means of the X-Ray, we see that callus formation takes place only on the lateral and posterior surfaces, while upon the medial and anterior surfaces, which are not covered by muscles, the bone formation is frequently reduced (Figs. 16–21). Transverse fractures of the femur and humerus heal rapidly, because they are surrounded by muscles in the whole of their circumference. The open operations which are frequently resorted to for the reduction of transverse fractures of the tibia and radius, are often followed by pseudarthrosis, because the haematoma and the other callus-forming materials are removed. If one, however, in reducing the fractures of the forearm by an open operation, frees the fragments subperiosteally before they are put in alignment, a periosteal callus formation takes place due to the powerful irritation produced. For the same reason we see rapid healing in splintered fractures, because they possess much callus-forming material.

Figs. 16, 17
A compound splintered fracture of the tibia and fibula, with a rotation displacement at the upper end of the tibia, also with a convex deformity facing anteriorly and a valgus position. The fracture was due to the patient having been run over.

Pseudarthrosis takes place usually in the purely intra-articular complete fractures, such as in the neck of the femur and in the scaphoid of the hand, because the blood supply here is poor, there is no periosteum and no covering by muscles.

In these fractures, callus formation can therefore take place only when blood vessels grow from the spongeosa of the marrow cavity of one fragment to the spongeosa of the marrow cavity of the other fragment. The slightest movement of the fragments against each other destroys the newly-formed blood vessels and causes in consequence a resorption of the ends of the fragments and a failure of bony union. In these fractures we can avoid the pseudarthrosis, if we uninterruptedly immobilize the broken fragments long enough after the precise reduction. Since the blood vessels are few and small, and since the blood supply

is poor in these fractures, we must immobilize the latter for a correspondingly long time. The fractures of the neck of the femur should be immobilized for 6 to 8 months and those of the scaphoid of the hand for 6 to 8 weeks.

Our experience teaches us that the joint fluid is not corrosive and does not hinder callus formation. We have proven this with certainty since in the last ten years we have treated about 60 fresh fractures of the scaphoid of the hand and have always obtained bony union if we used a correspondingly long and uninterrupted immobilization.

Figs. 18, 19

Figs. 20, 21

Figs. 18, 19. Roentgenogram controls of the same case (Figs. 16 and 17) after ten weeks. Good axial alignment. Firm union of the upper fragment, while on the lower one a tender callus can be seen on the posterior and lateral sides. From a clinical examination the callus is still soft.

Figs. 20, 21. Roentgenogram controls of the same case as represented by Figs. 16 and 17 after six months. The extremity was capable of weight-bearing after four months following the accident. On the posterior and lateral sides of the tibia, much callus formation may be seen, while on the anterior and medial sides, the split in the bone is still to be seen.

Fractures of the ankle, which are always connected with the joint, and those of the lower end of the radius, which are also often in connection with the joint, are bathed by the joint fluid, but nevertheless always heal by bony union. The tear of the styloid process of the ulna often results in pseudarthrosis because the articular disc lies between the fragments. Fractures of the patella and the olecranon heal by bony union, if the fragments are brought into good position. In these cases, it is only possible to keep the fragments together, if we suture the torn extensor tissues together, since the diastasis of the fragments in these fractures is a result of the torn extensor aponeurosis.

The union of fractures in the apophysis fails to take place because the surfaces of the fragments do not touch each other on account of their deviation.

In fractures with poor nutrition or in purely intra-articular fractures, such as of the neck of the femur or the scaphoid of the hand, and also in certain transverse fractures, such as of the lower third of the tibia and the middle third of the radius, pseudarthrosis frequently takes place, especially if the fragments are allowed to move and rub against each other. On the contrary, fractures through the trochanter or in the neighborhood of the elbow joint, which are surrounded by short muscles, tend to produce a myositis ossificans or give rise to a luxurious callus formation. If the same fractures are reduced accurately and immobilized until bony union takes place, the callus, even in these fractures, is also found to be normal in size. In the lateral fractures of the neck of the femur, which have been reduced in a poor position, one frequently observes a luxurious callus formation arising from the peripheral fragment and a pseudarthrosis produced from the central fragment.

In comminuted fractures which are infected, we may also see a good callus formation, provided that drainage has been instituted at the proper time. If no drainage is provided for the splinters, they swim in the pus, becoming necrotic; the periosteum also becomes detached from the bone. If all the splinters are removed too early, a defect pseudarthrosis frequently takes place (see Böhler, Report of the Orthopaedic Congress 1922, p. 119—125).

In fractures which are operated in a recent stage by introduction of foreign material, especially such as Lane plates, pseudarthrosis frequently takes place. According to Henderson of the Mayo clinic, out of 250 cases of fractures treated in this manner, 66% developed pseudarthrosis and, according to Scudder, out of 32 cases, 70% developed pseudarthrosis.

It follows, therefore, from what has been expounded, that faulty treatment is in the greatest part responsible for pseudarthrosis. Of the mistakes responsible, we emphasize the poor reduction and the incomplete contact of the fragments with the resulting interposition of soft parts; the short and often interrupted immobilization, and also the removal of the callus-forming material, such as the haematoma and bone splinters. The lack of immobilization might also be responsible for the congenital pseudarthrosis in the fractures of the leg.

The fact that many surgeons have never seen a pseudarthrosis in closed fractures, is explained by the exact reduction and sufficiently long immobilization (Malgaigne, Bardenheuer, Böhler). This also seems to prove that the causes of pseudarthrosis are mechanical rather than bio-chemical. The great increase of pseudarthrosis in the recent statistics, is, in a great part, to be blamed on the modern methods of treatment. In the first place is the practice of the suture of fresh fractures

by means of deeply placed and large metallic foreign bodies. The extensive removal of the splinters in compound fractures and the treatment by massage and passive movements of the fractures with poor blood supply and poor callus formation, are also responsible for the production of pseudarthrosis.

In the definitely formed pseudarthrosis, the bone marrow is covered by a sclerotic layer of bone. Both ends of the fragments become atrophic and pointed, after which they become unable to touch each other on account of the diastasis.

In transverse fractures of the shaft, where there is close contact of the bone fragments, we can see a proliferation of the periosteum, which forms the whole circumference of the central fragment and surrounds the peripheral one in the shape of a conical goblet. The space between both fragments, partially covered by cartilage, contains free bodies occasionally. A mass is formed around the pseudarthrosis of thick scar tissue which increases if the movements of the fractured ends are more pronounced. The nutrition of this mass of scar tissue, as in every other tissue of this nature, is poor.

THE TREATMENT OF PSEUDARTHROSIS

Since a pseudarthrosis greatly diminishes the capacity of the extremity to function, many attempts have been made to avoid it or to cure it. Delayed bony union and actual pseudarthrosis have always been put in the same category. Many methods to cure the pseudarthrosis have been suggested from the olden days. The rubbing of the fragments against each other introduced by Celsus, also the acupuncture, igni- and electro-puncture and the introduction of bristles; also the insertion of ivory tacks and the injection of marrow (Wyeth, 1878) as well as the internal treatment with phosphorus (Wegener), have all been without avail. The newer remedies, especially the ossophyt, have also suffered the same fate. Many of those with fractures have been fed on egg-shells. The fact, however, that I have seen many cases of pseudarthrosis which have been fed with hundreds of egg-shells speaks against this remedy. The injection of blood between the fragments (Bier), and the modern hygienic treatment with light and air and also the feeding with foods rich in vitamines, have only given results in cases of delayed callus formation. In this connection, our observations give no definite results after the use of vigantol. The sufficiently long and the uninterrupted immobilization of the fragments until solid union takes place with a simultaneous and ample use of the injured extremity is and remains the best method by means of which healing a bone takes place. This result we can also obtain in delayed callus formation, especially in the transverse fractures of the tibia and the radius. It must be emphasized that in the extremities, the weight-bearing on the callus should be in the proper axis and should not produce a bending or a rubbing. Excessive

Figs. 22, 23

Figs. 24, 25

Figs. 26, 27

Figs. 22, 23. Pseudarthrosis of both bones of the forearm one year after the injury. Three operations were unsuccessful. A bone fragment introduced during one of the operations is seen in the central part of the ulna.

Figs. 24, 25. Roentgenograms of the same case as shown in Figs. 22 and 23 six weeks after the operation. The ends of the four fragments were cut away and the bones freshened in a longitudinal direction and each pair of fragments fixed by a transplant from the tibia, consisting of periosteum and bone marrow.

Figs. 26, 27. Roentgenograms of the case shown in Figs. 22–25 one year after the operation. The transplants are healed by firm union. The function of the arm has completely returned.

continuous pressure of the soft parts leads to atrophy of the fragments. If, on the other hand, there is an intermittent pressure which is directed in the long axis, as in walking, callus formation is increased on account of the irritation. In fractures which are infected, union takes place surprisingly rapidly after the sequestra, or the metallic foreign bodies which were used, are removed from between the fragments.

In fractures of the shaft of the long bones with non-union, we must wait from six months to a year, before we are allowed to pronounce

Figs. 28, 29

Figs. 30, 31

Figs. 28, 29. The defect in the tibia, which is 16 cm. long and from which the graft was taken, is well seen.

Figs. 30, 31. Roentgenograms of the case represented in Figs. 28 and 29 one year after the operation. The defect is filled out. The tibia is a little smaller, but the cortex is thicker.

the case as a definite pseudarthrosis. In these cases, the resection of the bones, which was recommended by White in 1760 gives the best results. In many cases it is also advisable to add a bone graft first recommended by J. Wolff and Ollier, and then carried out by Nussbaum. The splintering of bone which was recently recommended by Kirschner, has not been tried sufficiently; we therefore reserve an expression of opinion for the future. The technical points related to the resection of the ends of the bones and to the grafting of bone, has especially been elaborated by Lexer and by Albee. Brun, Hohmann and others, have furnished important contributions to the same subject. The incision should be a longitudinal one, cutting through the skin,

soft parts and the periosteum, which is separated around the bone (a curved incision is apt to be followed by necrosis of the corners and a late infection in the depth). By penetrating through all the layers of the tissues down to the bone, the periosteum is left in complete contact with the soft parts and is therefore well nourished. The scar tissues are carefully cut away until the muscles and other tissues are seen to be normal. The eburnated ends of the bones, which close the marrow cavities, are cut away either transversely or in step form by means of a saw or a chisel, until one sees normal marrow. We must aim at a wide approximation of normal bone surfaces and marrow cavities. The newly-formed ends of the bones, which may be of various shapes depending upon the case, should be approximated and fastened together either by rustless steel wire or by kangaroo tendon (Figs. 22–31). A shortening has no particular significance in the arm, but an attempt should be made to prevent this in the lower extremity. The best way to prevent shortening is to transplant thick parts of periosteum and bone, usually from the tibia. The outlook for a favorable result depends on the excision of all the scar tissues, the covering of the wound with normal skin and the exact immobilization of the bones until healing takes place. If the skin covering the pseudarthrosis consists of much scar tissue, it must be excised and, where necessary, the use of plastic incisions should be resorted to. If there is a pseudarthrosis of one bone of the forearm with a defect, it is advisable to shorten the other bone and to leave out the transplantation, especially if the skin is considerably involved. In operating on pseudarthrosis of the tibia, the fibula must always be divided also.

Fig. 32

Cavity formation and atrophy of the scaphoid three months after the accident. The patient was treated without any immobilization.

In 1926 we operated eight cases of pseudarthrosis, who had already had one or more operations. These were as follows: One, both bones of the leg; two, in the tibia alone; one, in the fibula alone; two, in both bones of the forearm; one, in the radius alone, and one, in the humerus. Of all these cases, we only experienced one failure. This was a pseudarthrosis of the tibia in a woman who had also suffered from a severe nephritis. The transplant at first was in good position and progressed normally, but after eight months, it slowly absorbed at the site of the old fracture. From the time of this observation, we do not graft bone on the medial side of the tibia, which lies directly under the skin, but on the lateral side, which is covered by muscles and where callus formation first takes place in recent fractures.

Other operations, which are frequently performed, such as the scraping of the ends of the bones, or the approximation of these ends without the removal of the sclerosed parts of the bones, or the uncovering of the bone marrow, and without the removal of the scar tissue, all give bad results. The use of metallic supports or other foreign bodies is also of no avail.

The transplanted bones must be treated with the greatest of care. We can learn very much from gardeners and agriculturists. When grafting twigs to the trees they carefully prepare a freshly opened bed and fasten the young grafts, avoiding screws, nails or any other foreign bodies.

Fig. 33

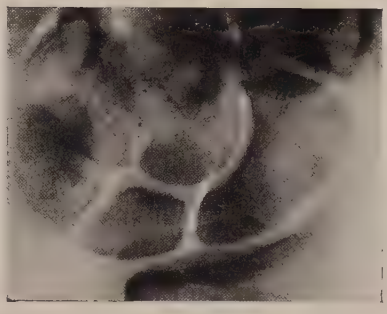


Fig. 34

Fig. 33. Roentgenogram of the same case as in Fig. 32. After eight months of immobilization by means of a dorsal plaster splint, the cavities in the scaphoid have disappeared, the fragments are healed by bony union, and there is only a fine slit to be seen on the radial side. The atrophy of the bones of the hand has disappeared. The wrist-joint movements were completely free after the splint was taken off, because the patient was able to use his hand during the whole period of the treatment. Before the immobilization he avoided the movements on account of the pain.

Fig. 34. Roentgenogram of the same case as in Figs. 32 and 33. Four months after the cast was taken off, the slit in the scaphoid on the radial side has disappeared.

Fractures of the patella and olecranon with non-union, can only be treated by excision of the scar tissue and the ends of the bones and by suturing of the aponeurosis.

The old fractures of the scaphoid of the hand, with cavity formation, are best treated by immobilization. We have treated many of these cases, some of which were over two years old, and obtained bony union with disappearance of the cavity. We immobilize the carpal bones by a dorsal splint, which is non-padded and reaches from the base of the fingers to the elbow, and which is left on continuously from 4 to 8 months. Such a splint permits the patient to use his hand. In closing the fist there is an intermittent longitudinal pressure on the ends of the fractured bones. The lateral movements are avoided on account of the splint (Figs. 32–34).

THE ORGANIZATION OF FRACTURE TREATMENT

Most of the clinicians, even to this day, teach that every practitioner can and should treat any form of fracture. The experiences of every day life, and especially the statistics of the accident insurance companies, speak against this statement. The most common fractures, such as those of the clavicle or Colles' fractures can be treated outside of the hospital, provided there are no special complications or displacements. One will rarely obtain a proper healing of a fracture of the femur treated at home, because the necessary care and adequate apparatus, and especially the X-Ray examinations are not conveniently at hand.

The methods in industry, traffic, and partially also in agriculture, are being progressively standardized and improved. The capacity for production is therefore greatly increased.

On account of specialization and standardization, the modern complicated economic life is becoming more efficient in its methods. These modern tendencies are little applied to the treatment of fractures, to the detriment of the individual patient and to the state. There are many and often large hospitals, where the X-Ray room is far removed from the operating amphitheatre and occasionally it is even in another building. It is therefore impossible to obtain immediately a control X-ray picture in order to ascertain, if the reduction was successful. We have arranged our clinic in such a way, that the receiving- and plaster-room where the patients are first admitted, lies between the X-Ray room on the left and the operating room on the right. If, after the clinical examination, a fracture is either diagnosed or suspected, the patient is at once placed on the X-Ray table. If open wounds are present, the patient is at once taken to the operating room, where the wound is adequately excised and sutured. In this way a compound fracture becomes a closed one and is treated as such. The patient is now brought back into the plaster room and the fracture reduced and immobilized either by a plaster cast or an extension dressing. People having fractures of the arm, walk unassisted into the X-Ray room for a control examination, while those with fractures of the lower extremity are carried on a wheel-stretcher.

Every splint, every bandage, every circuit of the bandage, every manipulation, and every tie is standardized. If some innovation is justified in the use of any apparatus, all of them are modified in order to avoid having different types of the same. All the parts have the same measurements, so that they can at once be exchanged.

BANDAGING MATERIAL AND APPARATUS

In order that a fracture be properly reduced and treated, we need simple, uniform and adequate material. If the bandages and the other necessary apparatus are of different sizes, it usually happens that the

particular size, which is needed for a special case is lacking. There is always one or the other thing wanting, causing an unnecessary and sometimes audible excitement which has an unfavorable effect on the patient. If all the necessary material is well and adequately prepared, the physician can direct the whole of his attention on the reduction of the fracture and the application of the bandage without being hampered and irritated by the treachery of the material. The following items are needed for the reduction and treatment:

(1) A suitable bed (Figs. 35, 36).
(2) A screw traction apparatus for the lower extremity (Figs. 37–39).
(3) A screw traction apparatus for the upper extremity (Figs. 41 43).
(4) A splint for the lower extremity (Figs. 45–48).
(5) A splint for the arm (Figs. 49–51).
(6) A wooden overhead frame for the fractures of the femur (Fig. 52).
(7) A wooden box.
(8) Pulleys (Figs. 53, 54).
(9) Exercising stand for the knee (Fig. 55).
(10) A rustless Steinmann nail with a U-shaped tractor and also a hammer (Fig. 56).
(11) Ice tongs (Figs. 57, 58).
(12) Rustless steel wire; also a U-shaped iron for extension and a drill (Fig. 59).
(13) Cramer's wire splinting made of various sizes (Fig. 60).
(14) A splint for the clavicle (Fig. 61).
(15) A special "redresseur" for the heel (Fig. 63).
(16) Splints for the fingers made of soft wire (Fig. 62).
(17) An iron walking heel; iron wrenches and flat pincers (Figs. 64, 65).
(18) Drill, hammer, file, forceps (Fig. 66).
(19) Adhesive plaster.
(20) Small boards and tractors for extension (Figs. 67, 68).
(21) Strong string.
(22) A narrow bladed knife, tissue forceps, scissors and a needle holder.
(23) Bandage scissors; plaster scissors and a plaster opener (Fig. 69).
(24) Plaster bandages.
(25) Starched bandages.
(26) Cotton and sheet wadding.
(27) Sterile sponges.
(28) Calico and gauze bandages (Fig. 70).
(29) Zinc-gelatine paste (Fig. 71).
(30) A wide brush (Fig. 71).
(31) Mastisol.
(32) Tincture of iodine.
(33) Balsam of Peru.
(34) Local anaesthesia paraphernalia: Novocaine, Record syringes, needles, sterile forceps and scissors, sponges. See p. 16 (Fig. 15).

In reference to the above mentioned items the following comments are of importance:

(1) Of great importance is the *position of the patient.* The patient with a fracture of the trunk or the extremity, can only lie comfortably, properly and free from pain, if the bed is hard and even and does not sink anywhere. The bed is prepared in such a manner that boards are introduced between the steel or spring wire mattress and the horsehair mattress above in the whole of its length and breadth (Fig. 35). If there

Fig. 35

Fig. 36

Fig. 35. A typical bed raised to its highest position. The spring mattress is covered by boards.
Fig. 36. The foot of the bed with four screws on each side. This makes it possible to raise the bed to three different heights.

are only straw mattresses at hand, they must be very tightly and adequately stuffed. During the War, on account of the lack of straw, we used shavings with the best results (Fig. 145). Then it is an easy matter to smooth out the sheet and to maintain it in a smooth condition by means of a second sheet placed and pulled across. Decubitus lesions from lying on folds and wrinkles can be thus avoided. The weight extension apparatus maintains a straight position without turning or tilting. For patients who remain a long time in a recumbent position, a higher bed is advantageous since the nursing and the treatment is facilitated and since the nursing personnel and the physicians need not stoop too much. For patients who walk about, the bed should be lower so that they need not climb into it. On this account we fix four screws

to every leg of the bed in order to raise or to lower the bed as desired (Fig. 36).

(2) Most of the fractures can be reduced and fixed by manual manipulation only, while in many, especially in the difficult cases, the screw traction apparatus is used with greater advantage. The benefit of this apparatus consists in the fact that we are able to exert an even, very powerful pull which is devoid of any injurious effects; and that the bandage can be applied

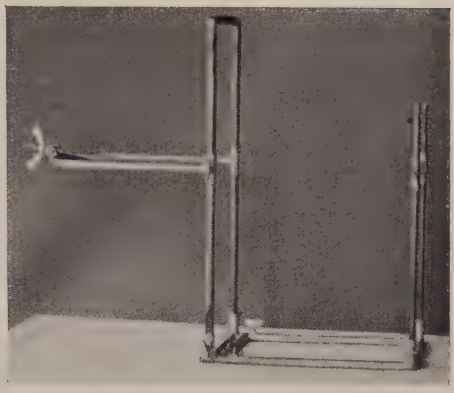


Fig. 37

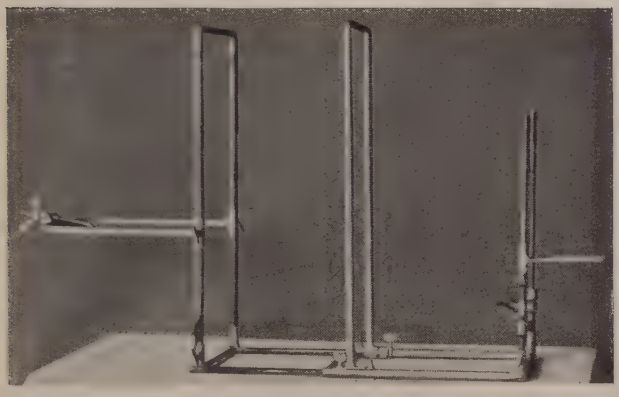


Fig. 38

Fig. 37. Screw traction apparatus used for the reduction of fractures of the leg, the astragalus, and the os calcis.

Fig. 38. The same screw traction apparatus as represented in Fig. 37, but elongated, and with the addition of another, U-shaped vertical attachment and also a pelvic support used for fractures of the knee-joint and also for fractures of the femur.

Fig. 39. Screw traction apparatus represented in Fig. 38 disjointed and ready for transport.

without being disturbed by the hands of the assistants.

The *screw traction apparatus for the lower extremity* (Figs. 37–39) consists of a right-angled sliding frame with two vertical rods on the central end, and with a vertical U-shaped attachment on the peripheral end. On the vertically placed rods at the central end, there is a transverse piece of iron which can be moved up and down; this iron piece is changeable

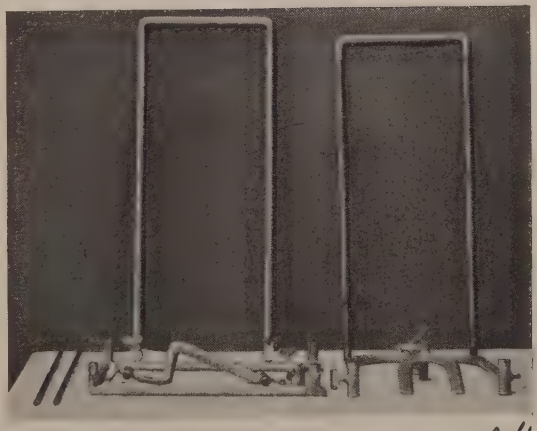


Fig. 39

see page 146.

and has one side bent in such a way as to adapt it to the flexor tendons on the inner side of the knee. On the distal vertical U-shaped iron is attached a horizontal U-shaped frame which can be moved up and down; the latter is provided with a hook on which a key can be screwed to exert extension. The axis of the screw attachment can be changed so that a pull can be exerted in any desired direction. This apparatus is employed for the reduction of fractures of the heel, the astragalus and the bones of the leg. If this apparatus is pulled apart and the pelvic support attached to one of the proximal rods, and another U-shaped rod attached to the middle, it can be employed for the reduction of fractures of the upper end of the leg and also the thigh (Fig. 38).

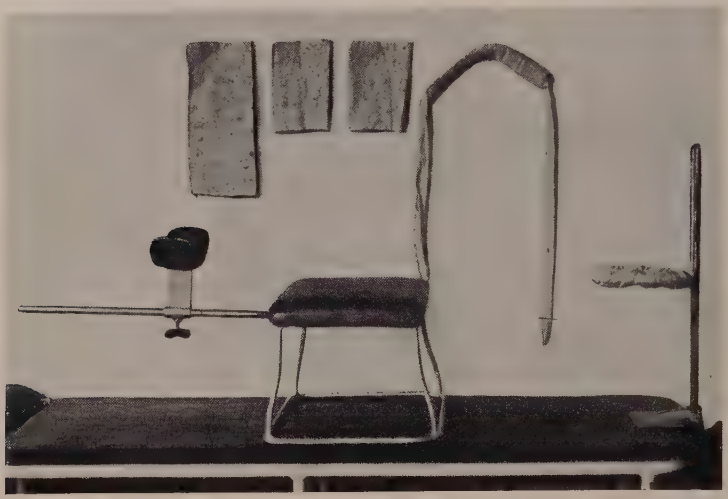


Fig. 40

Supports for the pelvis and also for the chest and for the head. On the wall are four different pads used in connection with the application of a plaster of Paris cast on the pelvis.

(3) The *screw traction apparatus for the arm* (Fig. 41) consists of a frame which is applied to the chest. At a right angle to this is a horizontal frame which has at its end a hook on which a key can be screwed to exert a pull. Both rods of the horizontal frame are bent to give room for the forearm when it is placed at a right angle. Another horizontal frame is attached to the part of the frame which is bent. The hand is supported on this frame which can be shortened or elongated and which can be changed from one side to the other side. The same apparatus can therefore be used for either the right or left arm. It is provided with three straps which are used to fasten the apparatus to the chest. It is used for the reduction of fracture dislocations of the shoulder, for difficult fractures of the humerus and also for fractures of the tarsal and metatarsal bones (Fig. 231). If the horizontal

frame is taken off and placed vertically under the screw attachment, this apparatus can also be used for fractures of the forearm (Fig. 42). For this purpose (*fractures of the forearm*) we can employ a special frame provided with a screw, a hook and a key, which is placed on the right-angled four-footed basal frame (Fig. 43).

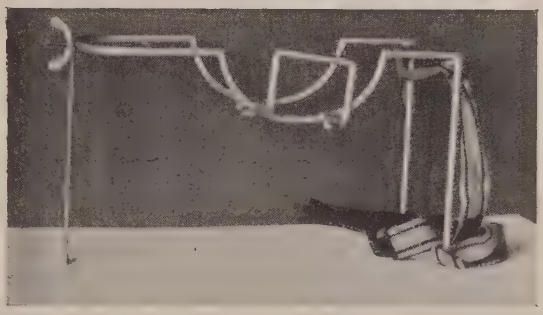


Fig. 41
Screw traction apparatus for the arm.

(4) In treating fractures and injuries of a joint, it is considered, from a theoretical point of view, advantageous to put all the joints in mid-position with the muscles relaxed; also to institute active movements as soon as possible and to employ continuous extension. Actually, this form of treatment is not as frequently exercised as it should be. The cause for this failure lies in the fact that it is difficult or impossible to put the fractured extremity in the desired position of flexion, without an adequate apparatus. Much more difficult is the demand that only the seat of the fracture be immobilized, and the neighboring joints allowed to move freely. Until a short time ago, it was the rule to immobilize all the neighboring joints next to the fracture.

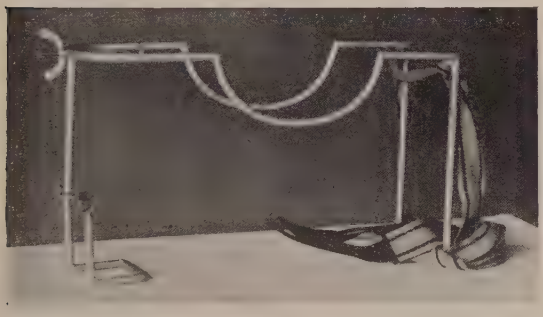


Fig. 42
Screw traction apparatus, the same as represented in Fig. 41, prepared for the forearm.

J. L. Petit was the first one to construct an apparatus on which the extremity could rest with all the joints in mid-position. He demonstrated this apparatus 200 years ago (1719) before the Academy of Science in Paris (Fig. 44). All the later splints for the leg were built according to the principles laid down by Petit, until Zuppinger again suggested treating fractures with the muscles relaxed. This prin-

Fig. 43
Screw traction apparatus for the forearm.

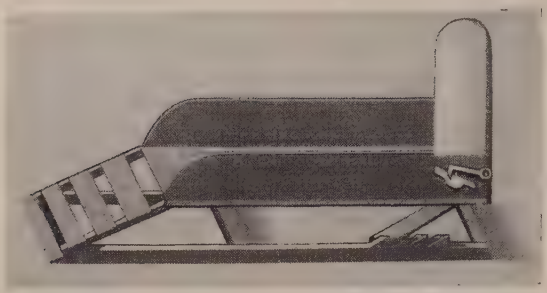


Fig. 44

Petit's splint for the lower extremity. All the later splints were based on the same principles.

ciple had, however, already been taught by Pott a century and a half ago.

In spite of the advantages which these splints have had, they were too complicated. The simplest splint for this purpose, constructed by Braun, was described in 1916. It consists of a simple frame made of iron rods (Fig. 45). The frame is wrapped with bandages on which the extremity is well fitted. Compound and infected fractures can be adequately treated by making windows in the bandaging and making provision for the drainage of pus. At the distal part, the foot is suspended from a U-shaped iron attachment by the use of adhesive plaster in order to prevent pressure on the heel and also a drop-foot. A small board introduced between the adhesive plaster gives sufficient room so that the toes can be freely moved.

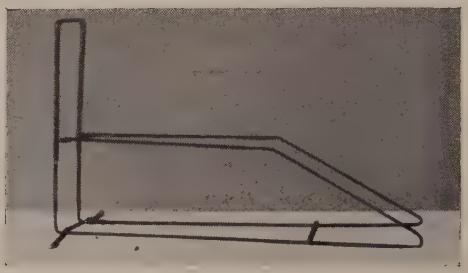


Fig. 45

Braun's splint for the lower extremity.

On account of the fact that it is sometimes troublesome to arrange the necessary pulleys for weight extension on the bed, I have constructed a modification of Braun's splint. It consists in the addition of a U-shaped, horizontal iron which carries one pulley on it (Fig. 46). This has the advantage that it saves time and that it is always in the axis of the leg and at the proper height. In certain fractures, especially in those near the ankle-joint, it is frequently impossible to get along without a lateral pull. The attachment of pulleys to the bed, especially if the leg is placed in a high position, can sometimes be very difficult. We therefore use pulleys which can be

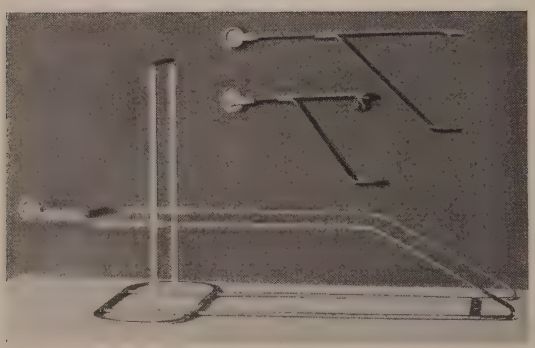


Fig. 46

A splint for the leg supplied with pulleys for lateral traction.

directly attached to the lateral side of the splint (Fig. 46). In place of the lateral pull, we can also employ lateral pressure. On account of the fact that the pads always slip out of place, my assistant, Dr. Schnek, has suggested that the rods of the U-shaped iron bar be bored through near their lower ends. In this way lateral pressure can be exerted by placing the screws through, to which are attached well-padded, cup-shaped iron appliances (Fig. 47).

Fig. 47

U-shaped iron appliance with holes bored through the rods, and supplied with pads for lateral pressure.

The treatment of fractures of the femur in semiflexion can be very difficult and troublesome, because most of the apparatus and splints suggested are quite complicated and difficult to handle. In addition to a whole series of screws, pulleys and rods, the splints are constructed of different sizes. The loss of one screw is often sufficient to make the whole complicated apparatus useless. The apparatus must be padded and wrapped. On account of this, the screws in the apparatus and also the other parts of the same, are so changed that the apparatus cannot be properly set up again. In order to overcome all these difficulties, I have modified Braun's frame to construct a *splint for the thigh*, which consists only of one piece (Fig. 48). One pulley is provided for the leg, a second for the thigh, and a third one for the pull on the foot. This apparatus can also be employed for the exercises of the knee joint.

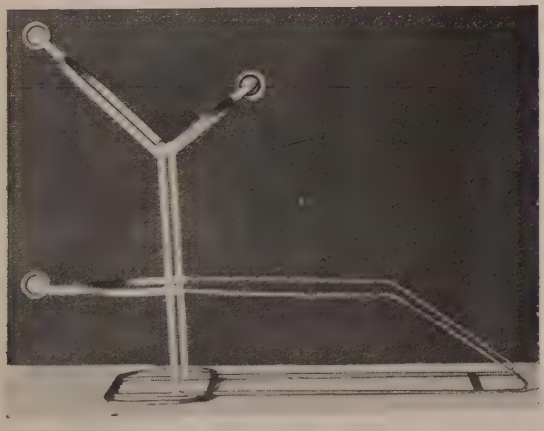


Fig. 48

Splint used for fractures of the femur.

(5) The aeroplane splint which is made of wood, consists of several parts. One of these is $40 \times 7 \times 1{\cdot}5$ cm. in size and is applied to the chest. The part for the support of the arm, is connected with the latter by means of a hinge; it is $45 \times 7 \times 1{\cdot}5$ cm. in size and is sawed off obliquely on its medial end so as to produce a posterior angle of 60 degrees and an anterior angle of 120 degrees. In this way the upper arm lies, not directly in the frontal plane, but 30 degrees in front of the latter. The under surface of the arm-piece

is provided with indentations between tooth-like projections. A narrow board is attached to the lower end of the chest-piece by means of a hinge and with its upper end, which is sharpened, fits into the indentations of the arm-piece; this wooden piece, which serves to support the splint, is 40 × 4 × 1·5 cm. A fourth board is used for the support of the forearm. It is 37 × 7 × 1 cm. in size and is attached to the arm-piece at a right angle (Fig. 50). Two flat iron ribbons 50 × 4 × 0·4 cm. are screwed down to the chest-piece and adequately bent (Fig. 50). These are used to avoid the displacement of the chest-piece. The splint, which is well padded, is fastened to the body by means of three straps. One is fixed over the chest, the second one over the abdomen, and the third one over the normal shoulder (Fig. 101). The straps applied transversely are each 90 cm. long and the one which goes over the shoulder is 110 cm. long. Additional belts 50 cm. long, provided with buckles, are supplied, two for each strap. In this way the splint can fit individuals of smaller or larger size. The flat iron ribbons should be well padded with cotton or sheet wadding.

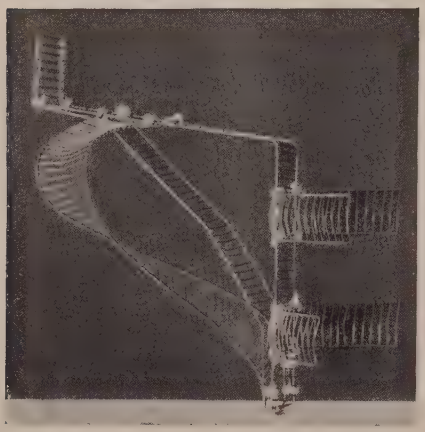


Fig. 49
Abduction splint (aeroplane splint) prepared from five Cramer wire splints.

The *aeroplane splints* can also be made of aluminium. The latter are very light and therefore more convenient to carry (Fig. 51).

These splints must be made separately for the right and left sides.

If the ready-made aeroplane splints are not at hand, they can be made by using five *Cramer wire splints*. Three of these are each 1 m. long and 10 cm. wide and the other two are each 60 cm. long and 8 cm. wide. One of the longer splints is bent at a right angle; the vertical part belongs to the chest and the horizontal part for the support of the arm, while the distal piece of the horizontal part is used for the application of extension. The second long splint is so fashioned as to

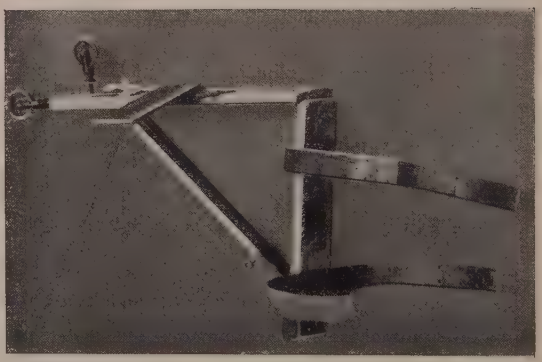


Fig. 50
An abduction splint made from wood.

support the forearm, it then follows obliquely towards the pelvis. The third of the long splints is directed from the pelvis to the elbow and its prolongation also serves for the application of extension. The two short splints are attached to the chest-piece and are used to prevent the slipping of the splint from the chest wall. All the five splints are fastened together by means of gauze bandaging (Fig. 49).

The wire splints are especially serviceable for the application on deformed chests, since, unlike the ready-made aeroplane splints, they can be moulded in any shape desired (Fig. 49).

(6) The *Balkan frame* consists of two vertical and two horizontal rods, also two pulleys attached on two pulley-carriers and one scissors-shaped wooden appliance. One of the vertical rods is slit open in the middle to admit the pulleys, which can be placed to any height desired. The lower pulley-carrier is shorter than the upper one, in order to avoid the friction of the weights (Fig. 52).

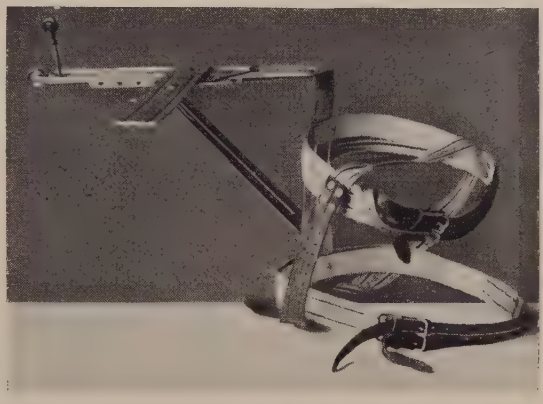


Fig. 51

An abduction splint made of aluminium and supplied with straps.

(7) The *wooden box* measures $25 \times 30 \times 40$ cm. and is used for the support of the normal foot.

(8) If a ready-made splint for the leg or for the thigh is not at hand, or when it is necessary to place the extremity in an extended position, we can employ a *pulley-carrier*, which is supplied with two iron hooks (Fig. 53). If there are wooden beds present, a pulley-carrier can be made by nailing three small boards together (Fig. 54).

(9) Patients with a fracture of the femur placed on a Braun splint can only flex their knees to an extent of 120°. If the *knee exercise appliance* is used, the knee can be flexed beyond a right angle. This knee exercise appliance, which is made either of wood or iron, is also used for the treatment of stiffness of the knee. This appliance consists of a base on which two rods are vertically placed; these rods are provided with indentations into which a transverse rod can be placed at any desired height (Figs. 55, 142).

(10) The most efficient and least injurious pull is the one exerted directly on the bone. For this purpose *Steinmann's nail*, which is 4–5 mm. thick, and which should be made of rustless steel, is best suited in most of the cases. The nail is driven into the bone by the use of an ordinary

hammer under local anaesthesia; it is then connected with the U-shaped tractor, to which a string is attached for extension (Fig. 56).

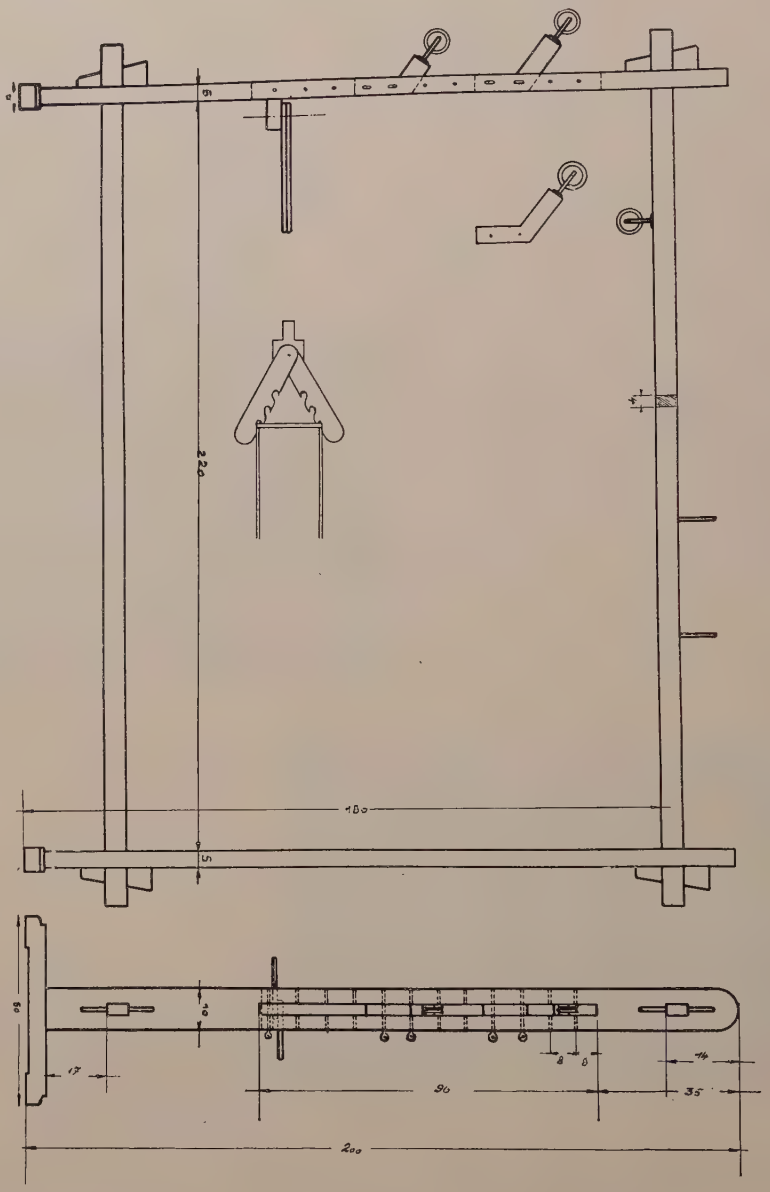


Fig. 52

A Balkan frame for the treatment of fractures of the femur and fractures of the pelvis. It consists of two vertical and two horizontal rods, two pulley-carriers and one wooden scissors-like appliance which serves to keep the splint in place.

(11) In place of the nail, we may use *ice-tongs* supplied with sharp, rustless points, such as those suggested by Schmerz. Those supplied with only one spring are very stiff. It is therefore better to employ

those which have three springs (Fig. 58). The tongs which are supplied with a hinge are easier to introduce and to remove. In order to prevent

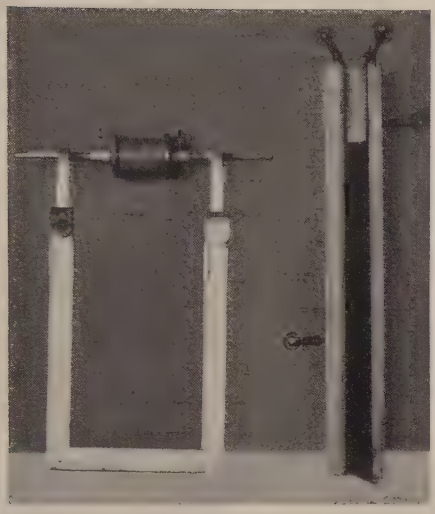


Fig. 53 Fig. 54 Fig. 55

Fig. 53. A simple pulley-carrier which can easily be attached to the bed.

Fig. 54. An improvised pulley-carrier made from three boards.

Fig. 55. An apparatus used for the exercise of the knee; it can be lowered or raised at will. See Fig. 142.

the displacement of the clamps, which might happen in a restless patient, they are fastened with a transverse piece (Fig. 57).

(12) In place of the nails and the ice-tongs, a rustless wire 2 mm. thick can also be used. A wire 15 cm. long, sharpened at one end, can be introduced through the bone by the use of a drill; a small incision is made in the skin with a tenotomy knife before the drill is introduced. The wire is held taut by using *Beck's tractor* (Fig. 59). For extension exerted on the fingers and on the toes, a rustless steel wire 0·5–1 mm. thick is used.

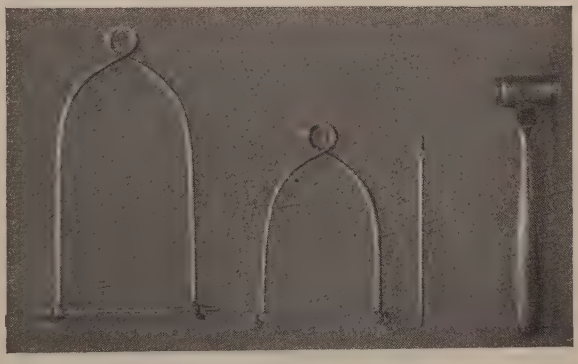


Fig. 56

Rustless Steinmann nails with the U-shaped tractors and a hammer.

(13) Aeroplane splints, and every form of transportation splint can be made by using *Cramer's wire splinting*. The latter are light, elastic

but nevertheless quite strong. They consist of two strong longitudinal wires which are connected by slightly curved transverse pieces of wire (Fig. 60). The wire splints, made in the manner described above, but in which, in place of the curved transverse pieces, only straight wire, surrounded with very fine wire, is used, are not very good, because they are weak, non-elastic and may lead to one injuring himself working with them.

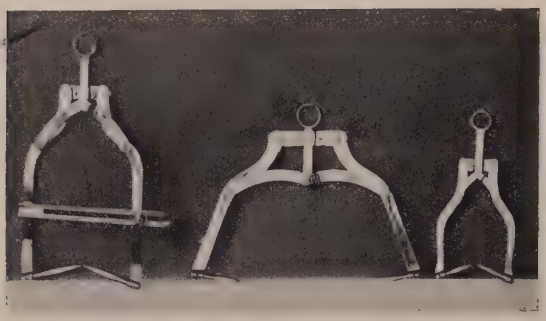


Fig. 57
Tongs made of rustless material constructed by ourselves.

(14) For the treatment of *fractures of the clavicle*, the splint employed consists of a wooden piece 30 × 15 × 5 cm. in size, which is tapered at its upper end. Another wooden piece 40 × 16 × 1 cm. in size is attached at a right angle to the lower end of the first piece; it is used for the support of the forearm. The second wooden piece can be pushed to one side or the other and the splint can therefore be used for either the left or the right side. It is fastened to the trunk by means of two iron ribbons and four straps (Fig. 61).

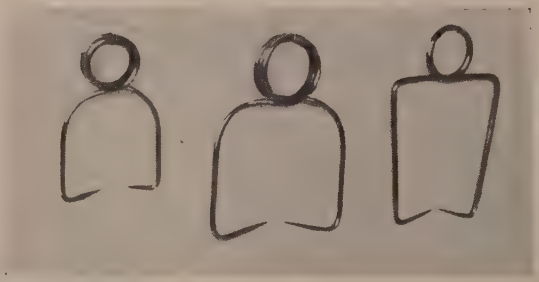


Fig. 58
Types of Schmerz ice-tongs supplied with one or three rings.

(15) For the reduction of the deviated fragments in compression fractures of the os calcis, we employ a heel "redresseur". The latter consists of a U-shaped iron piece provided with a powerful screw with two metal appliances or pelottes (Fig. 63). This apparatus can also be employed for the reduction of compression fractures of the knee joint.

Fig. 59
U-shaped tractor made according to Beck, also rustless wire and a drill.

(16) For the fractures of the metacarpal bones and the fingers, *wire splints* made of soft pliable iron wire 2 mm. thick are used; these are well padded. Steel wire is not useful for this purpose (Fig. 62).

(17) For the support of the heel, an iron U-shaped

rod is incorporated into the plaster cast; the iron rod is $50 \times 2 \times 0{\cdot}3$ cm. in size. At each end of the latter, a narrow band of iron $10 \times 1 \times 0{\cdot}1$ cm. is attached. The longitudinal iron piece is shaped by bending with an iron wrench, and the transverse pieces by bending with the flat pincers (Fig. 64).

(18) For the fashioning of the various splints, *drills, a hammer, files, and various forceps* are needed (Fig. 66).

Fig. 60
Cramer's wire splints.

Fig. 61
One clavicle splint supplied with iron ribbons and straps, and one without.

(19) For the extension dressings, we can also use *adhesive plaster* of various widths.

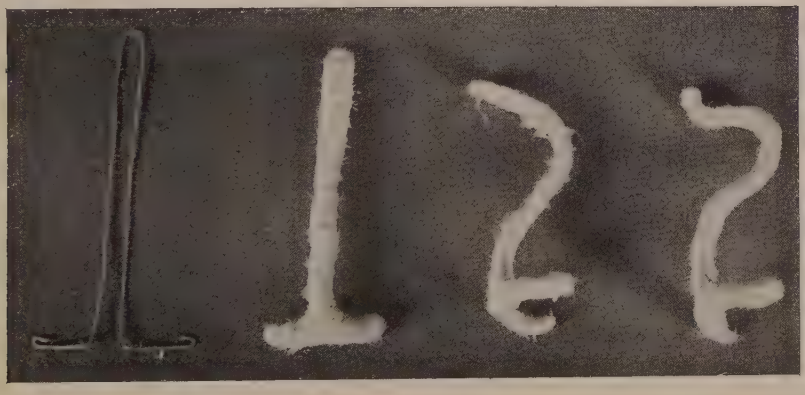


Fig. 62
Finger wire splints, padded and unpadded.

(20) The *boards* used to keep the extension plaster strips apart are 10×6 cm. in size for the femur, 8×6 cm. in size for the leg and the

arm, and 4 × 6 cm. in size for the foot. A hole is bored through in the middle of all these boards (Fig. 68). The pieces of wood used for the fingers and for the toes are 1 × 1 cm. or 1·5 × 1·5 cm. in size with a V-shaped section cut out on each end.

(21) *Hemp-strings* of various thicknesses are used for the extension.

(22) Ice-tongs and wire are introduced after incisions are made in the skin with a *narrow* scalpel. The thin wire used for the pull on the fingers and the toes, is introduced by means of a *needle-holder.*

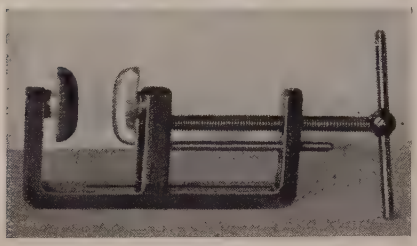


Fig. 63
A vice or "redresseur" for the calcaneus.

(23) A pair of strong *bandage scissors* is needed for cutting the cast; for opening of the cast, *plaster scissors* (Stille) are used, and for the prying open and removal of the latter a *cast opener* is employed (Fig. 69).

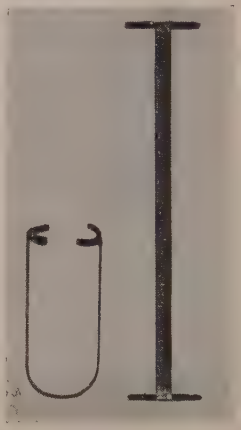


Fig. 64
A walking iron heel, straight and correctly bent for use.

(24) The most important and the best means of providing a firm bandage is the *plaster of Paris.* For the extremities, we employ plaster bandages of the same size; they are 5 m. long and 15 cm. wide, and

Fig. 65

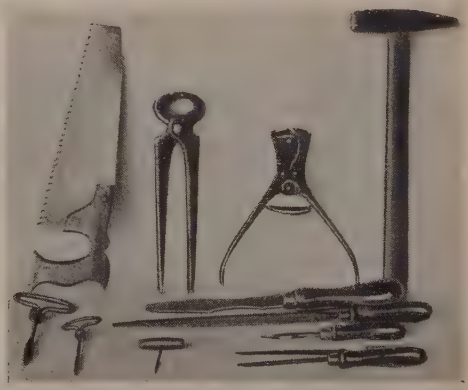


Fig. 66

Fig. 65. Wrench and flat pincers used to bend the iron heel.
Fig. 66. Saw, wire pincers, pliers, hammer, drill, puller, files, awl.

they are used both for adults and for children. For casts applied to the pelvis and the chest, bandages which are 5 m. long and 20 cm. wide are preferred. We must use only the finest alabaster plaster, and gauze

bandages which are narrow-meshed. The bandages 15 cm. wide, should weigh about 200 gm. and those 20 cm. wide about 250 gm. The starch bandages with plaster of Paris, which are used a great deal, are not as suitable, because they dry very slowly. The bandages are prepared by introducing them into plaster of Paris powder and rolling them slowly up. Grains of pap or wood should be avoided. When ready to use, they are introduced into cold or warm water and left there until no more air bubbles arise. Then they are lightly pressed out and ready for use.

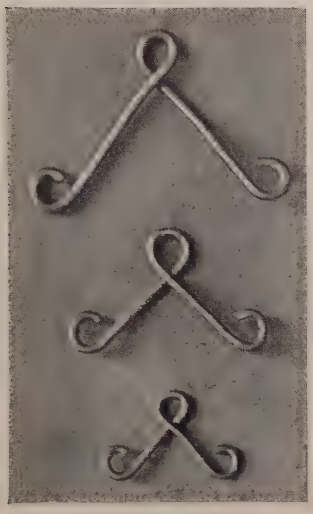


Fig. 67

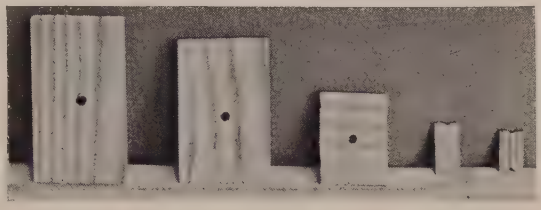


Fig. 68

Fig. 67. Strong wire tractors used in connection with the zinc-gelatine extension dressing.
Fig. 68. Boards of various sizes used in connection with extension by means of adhesive or wire.

(25) The *starch bandages* consist of an ordinary gauze bandage which has been introduced into a mass of starch. They are stiff and when they are introduced into warm water, they become soft and ready to be applied. They are used to cover and to protect the various dressings.

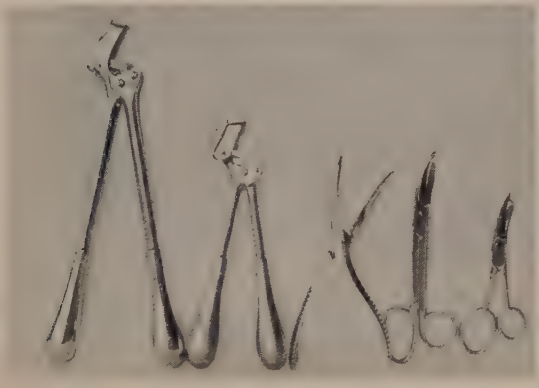


Fig. 69
Stille's plaster scissors, large and small, a plaster opener, large and small bandage scissors.

(26) *Cotton and sheet wadding* are used to pad wooden and wire splints.

(27) Wounds which have been made by the introduction of nails, tongs and wire are covered with *sterile sponges*, slit on one side.

(28) Plaster of Paris splints and padding are fastened by the use of either *narrow-meshed and strong calico* bandage or by the use of *wide-meshed gauze* (Fig. 70).

(29) The *zinc-gelatine dressing* is used for weight extension in fractures of the femur, also for the treatment of varicose ulcers of the

leg, varicose veins, arthritis deformans, and swellings of different natures. It is advisable to prepare the paste rather than to buy it ready-made. In order to make 10 kg. of this paste, we need 1 kg. of chemically pure zinc oxide, 2 kg. of good gelatine, 3 liters of water, and 4 kg. of chemically pure glycerin. If the material used is not good, the paste irritates the skin and produces an eczema. Otherwise, this paste is the

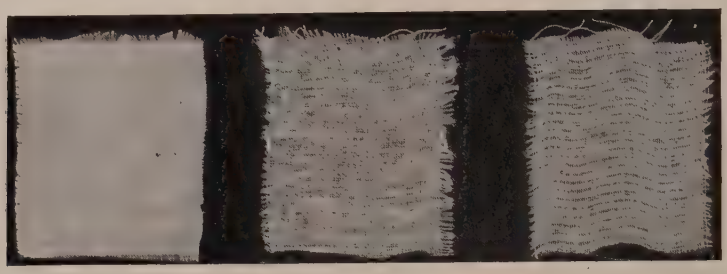


Fig. 70
Narrow-meshed calico bandages, and wide-meshed material for plaster bandages and zinc-gelatine dressing.

best means to heal the latter. The gelatine leaves are introduced into cold water (not warm) until they become quite soft; then the mass is forcibly pressed out. 2 kg. of water are added to the gelatine and the whole mixture put in a water-bath and mixed, until a uniform fluid mass is formed. 1 kg. of zinc oxide is mixed with 1 kg. of water until a thick paste is formed; it is then mixed the glycerin by stirring

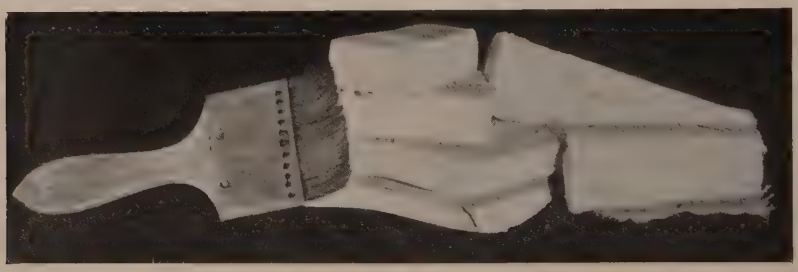


Fig. 71
Brush, zinc-gelatine paste and gauze bandages.

it forcibly. The same mixture is now introduced into the gelatine, which has in the meantime become fluid, and the whole mass actively stirred a few times. The zinc-gelatine paste is now poured into a flat receptacle. After 1 or 2 hours it solidifies and forms a white, elastic mass. It is used when necessary by cutting out the corresponding piece and liquifying it in a water-bath.

(30) The *brush* is 10 cm. wide (Fig. 71).

(31–33) Before any interference, the skin is swabbed with *tincture of iodine.* The sterile sponges are fastened with *Mastisol* after being covered with a few drops of *Balsam Peru.*

(34) For the local anaesthesia, *novocaine, record syringes, short and long needles* are needed, see page 16 (Fig. 15).

THE TREATMENT OF FRESH COMPOUND FRACTURES

When the skin and the other soft parts are so injured that the fragments communicate with the outside of the body, the fracture is spoken of as open or compound. If only blood escapes from the wound, we have to deal as a rule only with an open injury to the soft parts. If, however, drops of fat are seen to float in the blood, they originate from the bone marrow and the fracture is therefore a compound one. Bacteria are now able to penetrate into the depths and cause an infection of the torn soft parts, the bone and the bone marrow. If the skin is again closed in the first 6 to 8 hours after the accident, this danger can be avoided. The wound area is rendered free from pain by the use of local or regional anaesthesia. All the crushed and soiled tissues are excised. The hemostasis must be perfect. The assistants must be efficient. The danger of infection is greater in fractures from direct force than those from indirect force, and if the joint has also been opened, the danger is still greater. In fractures from indirect force, the skin is torn through or punctured by the fragments from the inside and is therefore relatively little damaged. On the other hand, in fractures from direct force, the skin is generally badly crushed and dirt and other foreign bodies are introduced into the wound by the violent force. The wound must therefore be enlarged in order to obtain a good view of the whole injured area. All the crushed edges of the skin and likewise all the soiled tissues, such as fat, fascia and muscles, must be sharply excised and removed. Soiled parts of the bone are also removed, either with a chisel or with bone forceps. Clean bone splinters are not removed, in order to avoid the danger of pseudarthrosis. The cleansing of bone with a brush and hot water is rather dangerous, because dirt and bacteria are in this way introduced into the spongiosa and into the bone marrow. After the wound appears quite clean, it is sponged with tincture of iodine, but only the skin, and not the other soft parts, is closed by closely-placed, interrupted sutures. Drainage is absolutely avoided. It is especially important to avoid the introduction of any foreign bodies into the depths of the wound. The use of large plates or screws for the fixation of the bones, is particularly detrimental to healing. With the above treatment, the open fracture is turned into a closed one and is treated as such (Figs. 72–77). The reduction of the fragments in the open wound is dangerous because the elevators introduced for this purpose are apt to cause new destruction. Of the last 26 cases of open

Fig. 72

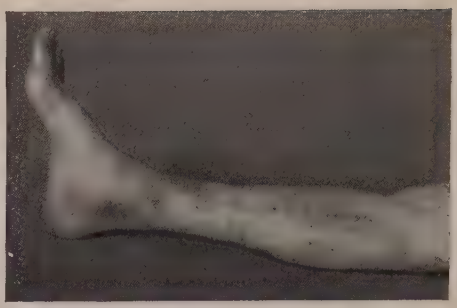


Fig. 73

Fig. 72. Compound fracture of the leg with protruding tibia, before the treatment.

Fig. 73. Photograph picture of the same case as Fig. 72 four months after the injury. The bone is in good position and the skin is healed with a smooth and movable scar.

Fig. 74

Roentgenogram of the same case as represented in Fig. 72 before the reduction. If, instead of reducing this fracture with a screw traction apparatus, the fragments are manipulated with an elevator in the open wound, the spongiosa is destroyed, bacteria are introduced into the depths, and new splinters are often produced.

fractures of the leg which were treated in our hospital, 25 healed by primary union and only one developed an infection limited to the site of the fracture. In the last case, the wound closed in eight weeks, after a small sequestrum was removed. After the preliminary treatment, and after the limb is put in a plaster or an extension dressing, the wound is left exposed by providing a window in the dressing; the wound is therefore treated by open exposure, without being covered by gauze. On account of the fact that the skin in the neighborhood contains blebs and superficial tears,

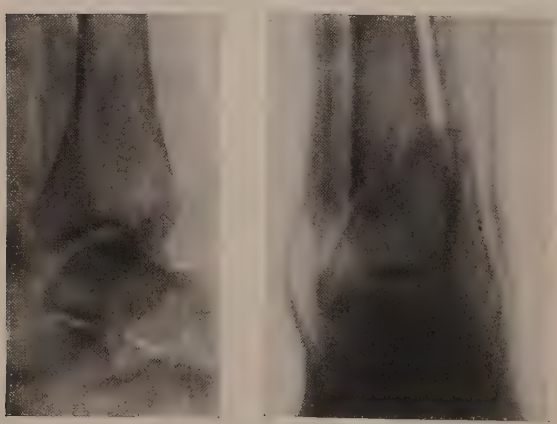


Fig. 75

Roentgenogram of the same case as in Fig. 74, after reduction with the screw traction apparatus.

it often begins to secrete. The sponges covering the wound, therefore, become moist, the skin becomes macerated, and the stitch-holes infected, the pus penetrating into the depths. By the open method of treatment, the wound remains dry. After the excision of the wound and the primary closure of the skin, there is often a considerable rise in temperature in the first few days. If the neighborhood of the wound, which remains open and can therefore be examined and watched, appears reddened and is painful to pressure, the sutures should not be removed if the neighboring glands are not swollen. In compound dislocations, the ligaments should also not be sutured. The ligaments are also torn in closed dislocations. No surgeon will expose and suture the ligaments in the latter dislocation, because experience has taught us that these always heal if the joint is adequately immobilized.

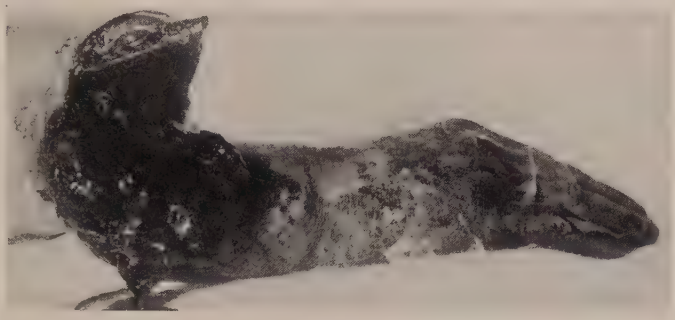


Fig. 76

Very extensive destruction of the forearm produced by a grinding machine in a mill. Both bones are fractured and all the soft parts on the extensor surface are torn. The most important blood vessels and the medianus nerve were left intact.

It is very dangerous to close the wounds without removing all the tissues with poor nutrition. Wounds treated in this way, may lead to serious infections and gas gangrene.

Fig. 77

Photograph of the same case represented in Fig. 76 a few months after the injury. All the crushed, ragged and soiled tissues were excised and the healthy skin sutured without drainage.

The wound cannot be considered clean by simply lavaging it out by means of antiseptic solutions, without removing the torn and soiled soft parts. The danger of using a strong solution of phenol, is especially emphasized by Hochenegg in his lectures. In some of the clinics during the "eighties" a compound fracture was a fatal injury. The fragments were exposed in the wound and treated so long with a phenol spray until they were white, i.e., dead. Hochenegg relates that during the early days of his assistantship, he was instructed to climb on a ladder so as to

increase the pressure of the "healing fluid". Those patients who did not die soon from the phenol poisoning, succumbed in a short time as a result of a serious infection or septicaemia. It is interesting to note that at the same time country physicians, who were not familiar with this form of antisepsis, obtained a good result in the majority of cases of compound fractures.

TREATMENT OF INFECTED FRACTURES

If an open fracture is admitted with high fever, or if it is more than 12 hours old, the wound should not be excised and the skin should not be closed. In these cases, provision must be made for adequate drainage, especially in those locations where there are thick muscles surrounding the bone, such as the femur. A good and a careful reduction of the fragments is particularly important in these cases, because large cavities which lie between displaced fragments, and which are apt to give rise to abscess formation, disappear after the reduction (Fig. 78). The blood vessels which have been compressed and displaced, are again free and the blood supply of the extremities is therefore improved (Fig. 79). The complete and uninterrupted immobilization of the well-reduced fragments is, in these cases, especially important. We must follow exactly the rules governing the treatment of wounds. *The wound needs for its healing the same conditions that any living animal or plant organism requires for its growth. These are, apart from light and air, first, time; second, rest; third, heat; and fourth, moisture.* Rest and time depend upon each other in an inverse proportion. *The more rest is given to a wound, the shorter time it needs for its healing.* We see, however

Fig. 78

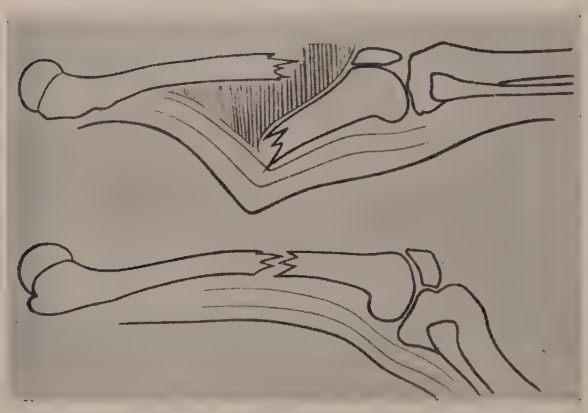


Fig. 79

Fig. 78. A supracondylar fracture of the femur with a typical displacement. The lower fragment is displaced backwards by the pull of the gastrocnemius. All the soft parts are separated from the upper fragment. The blood vessels and the nerves pass over the sharp edge of the lower fragment and are always in danger of being injured. A potential pus cavity is formed between both fragments (indicated by the shading). This is also the origin of the constant fever.

Fig. 79. The diagram of the bones in a properly applied dressing and with an adequate flexion at the knee-joint. The displacements are reduced, the blood vessels and the nerves are in no further danger of being injured, and the pus cavity between the upper and lower fragments disappears.

very frequently, that as soon as a rise in temperature takes place in patients with open fractures, the splint and extension dressing are removed, and only the wound treated as such. On account of the movements and the lavage, the wound is constantly irritated, and one often sees that after the dressing is changed, chills take place. It is especially dangerous to bathe the extremities with open fractures, because the fragments become easily displaced. On account of the movements, the organisms and the poison are spread over the body, with the result that many patients succumb on account of general septicemia.

Provision must be made for adequate drainage. The incisions should be guided by anatomical considerations and not always be made only in the most dependent part. All the pus accumulates within

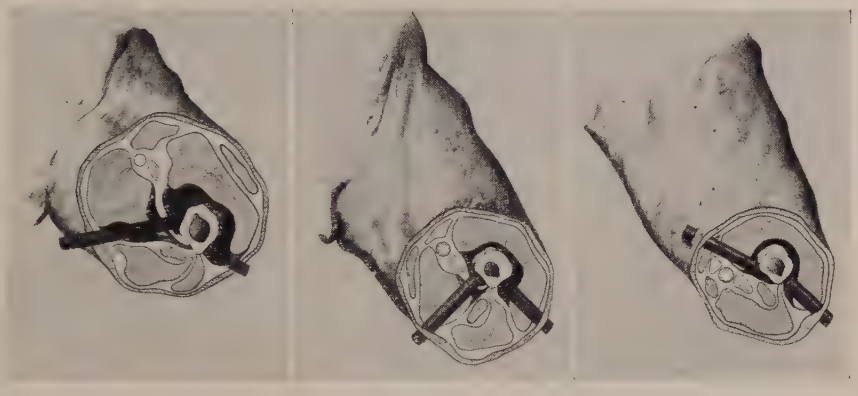


Fig. 80

Cross-sections through the upper, middle and lower thirds of the femur with a gravitation abscess and its drainage.

the fascial planes. The fascial spaces about the femur are so arranged (Fig. 84) that the extensor muscles surround nearly the whole of the femur throughout the length of the thigh, while the adductors are in contact with the femur in its upper half and the flexors, represented by the short head of the biceps are in contact only in the lower third (Fig. 80). The fascial walls are so firm that pus cannot penetrate from one fascial space to the other. It is therefore useless to drain a gravitation abscess of the thigh from the posterior side. As can be seen from figure 80, the drains must be introduced from each side in a V-shaped manner, in order to avoid the large blood vessels. If the drainage is too near the blood vessels, the latter may be eroded and a hemorrhage may often end fatally. Particularly dangerous in this connection, are rubber drainage tubes which are pulled through the interosseous spaces. If it is necessary to make incisions in the extremity for the purpose of drainage, the weight extension dressing or the plaster cast should not be removed, because this disturbs the immobilization and may lead to the displacement of

the fragments and a change in the course of the blood vessels and nerves; the latter may easily be torn (Fig. 81). Bone splinters should not be removed, because it is impossible to know which part of these will remain viable. If all the splinters are removed, a pseudarthrosis due to the defect in the bone is apt to take place.

Moisture and heat are furnished to the wounds by the circulating blood. The outside temperature must also be adequate, in order to influence the proper healing of the wound. The continuous irrigation of wounds often proves injurious because the solutions used are cold.

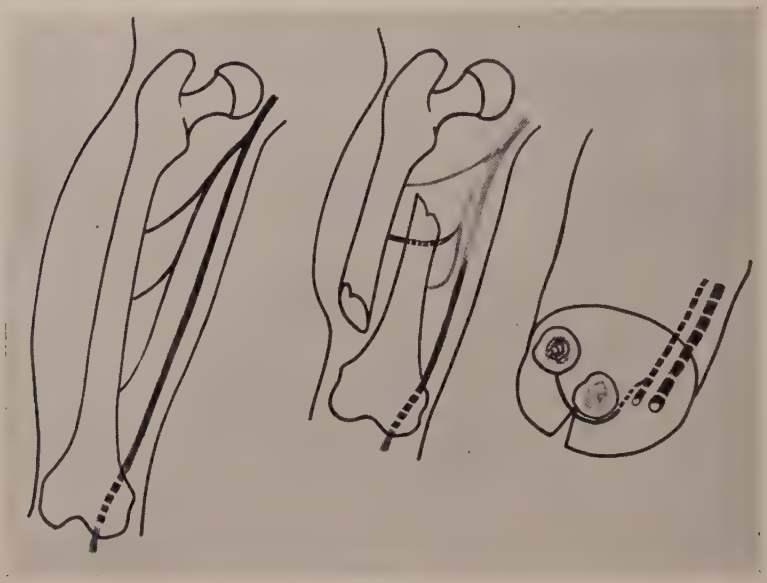


Fig. 81

(a) The course of the blood vessels in a normal femur.

(b) The course of the blood vessels in a fracture of the femur, with pronounced displacement of the fragments.

(c) On account of a longitudinal incision on the flexor surface of the thigh, penetrating down to the bone, the perforating arteries were severed. As a result of this a part of the bone 12 cm. long became necrotic. A diagrammatic representation of an actual case.

Some aim to keep the wound absolutely dry. This is impossible. It is fortunate that the wound cannot be kept dry, because to keep the latter actually dry, is tantamount to the death of the tissues. The best fluid to influence regenerating tissue favorably is the wound secretion which is of body temperature. This is very beautifully demonstrated in the healing of the large deep wounds on the anterior surface of the leg. If such wounds are treated by the open method and are left in peace, one observes that the large cavity fills with pus. Covering this a crust is formed and from the depths granulation tissue grows rapidly upward until it fills the large cavity in a short time.

The open treatment of wounds has various advantages. Its biggest advantage lies in the fact, that if this form of treatment is properly followed out, the wound is never disturbed. Many misunderstand the formation of crusts and believe that it indicates a drying of the wound; the crusts are therefore removed several times a day. On the contrary, the necessary moisture is found under the crust. The open method of treatment also prevents the decay of tissue and, consequently, the development of bad odors. The skin remains normal and does not become eczematous or macerated. This fact is particularly important, because wounds constantly become infected from a macerated skin.

The flow of the blood stream which brings the nutritive materials and the proper warmth to the wound, and in addition, the returned circulation, are influenced by a corresponding high position (Braun's splint for the lower extremity and the aeroplane splint for the arm) and by active exercises of the muscles of the uninjured joints. The whole secret of the treatment of wounds, and of the functional treatment, consists in the proper application of rest for the wound, and in the movement of the normal parts of the extremity.

The rules governing the treatment of fractures and the treatment of wounds, will always remain valid in the face of great advances in surgery which we cannot as yet even anticipate. All the new attempts to treat the wounds by antisepsis, by vaccines, or by irritation and light, will not prove successful, if the rules governing the treatment of wounds are not followed. The same applies to the treatment of fractures. The injection of chemicals and other means will not bring the desired functional result, if the fundamental principles are neglected.

OPERATIVE TREATMENT OF FRACTURES

The most disastrous innovation in the treatment of fractures is the operative reduction of the latter and the fixation of the fragments by the use of large, metallic foreign bodies.

Thousands of lives have been sacrificed on account of this procedure, and still more have been crippled. Osteomyelitis and pseudarthrosis are constantly seen as a result of this treatment; section of the radial nerve or of the peroneal nerve are also not infrequent.

The statistics of the insurance companies offer a destructive criticism of this method. Gray, of San Francisco (The Journal of Bone and Joint Surgery, Vol. X, January 1928), has collected 34,753 cases. He found that the time for the healing of fractures of the femur is twice as long when the operative method of treatment is used, as when the conservative method is used, and that the cost of treatment is three times as great; also that the compensation is twice as great in the open treatment. Of the fractures of the humerus, 56% were treated by an open operation. In these cases, the time necessary for the healing, also the expense of treatment and of compensation, were twice as great as in those cases

which were not operated upon. Of the fractures of the lower extremity, 40 % were operated upon; the time of treatment, the expense and the insurance indemnities were 50 % higher, than in those treated conservatively.

Dahl-Iverson has followed up 274 cases and found that 35 % developed some form of infection of the bone, and 7 % resulted in a pseudarthrosis.

Marbaix reported 10 cases of fractures of the femur operated upon by a certain surgeon, with 3 fatalities.

Eiselsberg reports 15 cases which were treated by Lane's plate. Of these 3 died, one had to be amputated; the last 4 cases had open fractures.

One surgeon treated 200 cases of fractures of the femur during the War, by the open method. He lost nearly all of these cases, and those that did not end fatally, had to undergo an amputation. And this occurred in spite of the fact that many of these cases were originally closed fractures.

The English surgeons at the beginning of the War, were performing the open method of reduction and the various methods of suturing of the bone, but the results were so bad, and the mortality so high, that this method of treatment was prohibited by the higher authorities.

Some surgeons have succeeded in performing a large series of these open operations without any infection. It appears, however, that several of these have had good results chiefly in very common fractures, such as those of the clavicle, or the shaft of the leg and not in those very difficult compression fractures with splintering into the joint.

The defenders of the open method of treatment state that it is impossible to reduce some fractures with difficult displacements without resorting to an operation. This, however, does not agree with our experience, since nearly every displacement can be reduced by a correspondingly powerful pull exerted directly on the bone. If, however, the complete reduction is not always possible, the patient with a slight shortening or other displacement is better off than the one in whom the bone fragments are in good position but who, as a result of the operation, is repeatedly annoyed for many years by a flaring up of the osteomyelitis or by an erysipelas, etc. He becomes a permanent visitor of the hospitals. As a consultant, one learns of many of such cases with a tragic fate.

The operative treatment is beset with many dangers, because every fracture is accompanied by extensive injuries to the soft parts; the force which causes the fracture also tears many of the blood vessels. The blebs which are frequently found on the skin, result from the disturbed circulation. If an operation is resorted to, the fragments must be widely exposed and more blood vessels are therefore injured. Operations on the bones, undertaken under normal circumstances, in the normal tissues and with an adequate technique, are nearly without danger. The most dangerous operation, however, is the open reduction and approximation

of the fragments in compound fractures, and yet many surgeons teach that exactly these fractures should be treated by approximating and suturing the fragments by the use of all sorts of foreign bodies. There are only a few fractures which cannot be reduced and kept in good position without an operation. To these belong fractures of the joint with a torsion of a part of the joint, such as seen for instance in the lower end of the humerus, also fractures with a diastasis, such as fractures of the patella and the olecranon, and the separation of certain apophyses.

THE NON-PADDED PLASTER CAST

Many text-books warn against the indiscriminate use of a plaster of Paris cast, because of the danger of stiffness of the joint and the atrophy of muscles. This mild warning is directed against the padded cast. Particularly forbidden, is the non-padded circular cast, because of the danger of pressure sores and especially of serious disturbances in the circulation with resulting ischaemic muscle contractures and gangrene. These dangers are actually present if a circular plaster of Paris bandage is used, but, by using an adequate technique and keeping a strict watch on the patient in the first few days, all these dangers can be avoided. The padded plaster cast should only be used to transport the patient, but not for the treatment, because the fragments are easily displaced. The padding cannot be uniformly placed under the cast and after a time it is displaced. Pressure sores are often seen under padded casts where there are uneven, bulging areas in the skeleton. If on the other hand a non-padded cast is carefully applied, the pressure is evenly distributed over the whole surface of the enclosed extremity, and there is therefore no uneven pressure in any particular place sufficiently strong to produce a pressure sore. Before the non-padded plaster cast is applied, it is important to press away the hematoma and the swelling. It is also important not to change the position in any way after the plaster is applied, because otherwise folds and pressure areas are apt to give a great deal of trouble. First a plaster splint is applied and then surrounded by circular turns. This bandage is actually not a circular cast in the old sense. The plaster bandages should not be tightly pulled, but only lightly thrown around. For certain fractures, as for instance, for Colles' fracture, a dorsal plaster splint alone is sufficient. The plaster must be applied, avoiding every fold, and when moulding near a joint is necessary, the pressure must not be applied in any limited area, but uniformly with the flat of the whole hand. For this purpose, practice and experience are necessary.

The skin should not be shaved or covered with grease before the bandage is applied. In this way the plaster becomes uniformly incorporated with the hair and holds better. Because the pull on the hair is uniform, the patient feels no pain. If grease is used on the skin, the bandage loses its hold and the plaster becomes impaired.

Swellings which take place after the application of the cast, can be relieved by raising the upper extremity on the aeroplane splint, and the lower extremity on Braun's splint. *In the first twenty-four hours, the fingers and the toes must be repeatedly and very carefully examined.* This is particularly important in those cases which have been bandaged immediately after the injury, and before the swelling has had time to appear. If the fingers or the toes become very much swollen and bluish or cold, and the various sensations are either disturbed or disappear altogether, the bandage must at once be split open. It is not always necessary to remove the bandage completely, because after it is opened, plenty of room is given for the blood to circulate freely, and the fragments can at the same time be maintained in a good position. *Severe pains which are frequently not relieved by morphine, are foreboding symptoms of a disturbed circulation. The various means for controlling pain are frequently without any result in such cases.* If the bandage is not removed at the proper time, the pains disappear in about one or two days, and this indicates that the death of the extremity has taken place. The bandage should never be left closed in the interests of a good position of the fragments when danger to the viability of the extremity is present. There is nothing so frightful as the loss of an extremity on account of a poorly applied bandage.

Every patient who is sent home with a non-padded cast should be verbally instructed, that he must return at once, if he begins to suffer any pains. The same instructions should also be given the patient in writing. This applies not only for the plaster casts, but also for all the other bandages. In this way the attention of the patient and all the others concerned, is directed to the danger which might result, if the instructions are not carefully followed. One also protects himself against unpleasant damage suits.

SPECIAL PART

FRACTURES OF THE SKULL

Fractures of the Vault

The prognosis in the fractures of the skull depends, not on the extent of the injury of the bony parts, but of its contents, that is, the brain. If there are only fissures present, and if the patient is unconscious the adequate and usual care must be provided. If the bladder is filled, it must be catheterised at the proper time.

In depressed fractures, the fragments which are driven in, must be raised to their proper level. The seat of the fracture is exposed by an incision of adequate size with the use of local anaesthesia. The bony fragments are then raised by using an elevator. If the fissure is so narrow that it is impossible to enter with an elevator, a hole is made in the adjoining normal bone with a trephine. If it is necessary, we may enlarge the hole with Dahlgreen's forceps. All the splinters are raised through this hole. The internal table is always fractured to a larger extent than the external one. If the dura is bluish and does not pulsate, it indicates that there is a hematoma under the latter. In this case the dura is split open, and the blood and destroyed particles of brain tissue removed by sponging. The dura should not be sutured. The bone fragments which have been raised, are properly replaced, and the skin closed over by using closely applied interrupted sutures.

In simple depressed fractures in children in the frontal area, where the cranium is only slightly depressed, the internal table is splintered to a lesser degree than in adults. For this reason such fractures often heal without an operation and without causing serious disturbances.

Compound fractures of the skull, if they are admitted not later than 8 or 10 hours after the accident, are treated by debridment and primary closure. The contused edges of the skin are excised until the normal limits. The smaller dirty splinters are removed. If there are large soiled splinters they are cleansed by gnawing away the dirty ragged ends with the rongeur. The torn dura is excised with scissors, and bone splinters, foreign bodies, and lacerated brain tissue carefully removed. The cavity is lavaged with Halogen fluid. The large splinters are properly replaced and the skin completely closed without any drainage. The placing of sutures in the depth of the wound should absolutely be avoided. The larger splinters should never be removed if one is to prevent large defects in the skull, because the latter give rise to very

serious disturbances. If drainage is used the danger of infection is great. The meninges and the brain itself are apt to become infected and abscess formation with a perforation into the ventricles is also apt to take place. If the wound is at once carefully and completely closed, a cyst forms in the place of the injury; much scar formation is thereby prevented and epileptiform fits rarely occur. If there are signs of an increased pressure in the spinal fluid with vomiting and a slow pulse, it can usually be relieved by a lumbar puncture. In case there is a persistent rise in temperature, the wound is punctured and the sutures only removed if there is pus. The patient must be kept in bed for at least four weeks after the injury. This is sometimes difficult to do because after a few days the patient is symptom-free. Of the last eighteen cases with compound fractures of the skull, and with injury to the brain, which were treated in the way described above, all healed by primary union. None of these had any defect in the skull and in none of these cases were there any epileptic fits. This, of course, does not take into consideration the patients with very serious injuries, who died in the first twenty-four hours after admission.

One of our recent patients was injured by a horse. The horse-shoe made a wound at the right side of the forehead, which penetrated four centimeters deep into the brain tissue. The defect in the bone was about five centimeters in diameter; there was all sorts of dirt, hairs and small bone splinters which had penetrated deep into the brain tissue. After the wound was carefully cleansed and the lacerated particles of brain tissue, together with the small bone splinters, removed, the skin was completely closed without any drainage. The patient felt well for the first two days. On the third day his temperature was F. 103·3°. The pulse was 44. He started to vomit and he was very somnolent. There was no inflammation in the wound. After the removal of 20 cc. of spinal fluid, the pulse increased to 60 in about an hour and a half, and the patient again felt refreshed. On the following day, the patient's temperature was normal and from the fourth day on, he was free from complaints.

It is particularly important to examine every open wound of the vault, caused either by a blow, kick or in any other way. The suspected area is exposed by an adequate incision, because one frequently finds fissures containing small foreign bodies or hairs in an otherwise innocent-looking laceration. This procedure is performed by the use of infiltration anaesthesia. In these cases we must bite away the dirty and ragged edges with a rongeur. We should never use a curette, because we are liable to displace soiled tissues and foreign bodies into the depths. If the lacerated edges of the wound and the ragged edges of the bone are not excised, and the skin is not closed, a slight infection of the wound, which at first sight looks harmless, takes place. This leads to an inflammation of the fissured bone and also the diploe. If the internal table is also fractured, pus accumulates beneath it because it has no

possibility of escaping to the outside. An inflammation of the meninges, and the formation of a brain abscess, is apt to occur weeks and even months after the injury.

Particularly instructive in this connection, is the case of a man who suffered an injury to his head from a beer-bottle during a quarrel in an inn. There was only a small, slightly oozing lacerated wound, and the patient was conscious and walked an hour and a half to reach his home. He worked three days without any complaints. On the fourth day he developed a headache and later also vomiting. On the seventh day he was admitted to the hospital with symptoms of meningitis and on the following day he died. The infection penetrated into the depths through a very narrow crack in the bone. The suspected assailant was imprisoned for ten years.

Fractures of the skull, with concomitant opening of the frontal sinus, are treated in the same way as the others. Also here we do a primary closure of the skin. We have seen no disturbances from this procedure, since the frontal sinus is usually free from bacteria. Many advise leaving these fractures open; this, however, according to our experience, in most of the cases, leads to an infection.

Basal Fractures of the Skull

In addition to the hematoma of the eyelids, these fractures are also characterized by hemorrhages from the nose and the ears. For the purpose of immobilization, we apply the collar after the method suggested by Schanz: this is also advisable in bad fractures of the vault (Fig. 82). It is especially important not to pack the nose, because the bleeding soon ceases, and not to *syringe out the ear.* The dried blood should not be removed from the ear cavity before four weeks after the injury. The syringing of the ears may lead to very serious damage, because many patients have developed meningitis, a complication which seldom develops in fractures of the base of the skull if they are left in peace.

Fractures of the base are operated upon when the middle meningeal artery is torn and when an *epidural hematoma* has formed.

The site of the injury is exposed by forming an osteoplastic flap. The blood clots are removed and the bleeding blood vessels ligated. If the latter cannot be picked up, their bony tunnels are plugged with catgut or with ivory.

Fractures of the malar bone, without any displacements, require no particular treatment; those with displacements are treated by an open operation.

Fractures of the upper jaw are reduced by manipulation from the inside of the mouth and if there are any pronounced displacements, the fragments are immobilized by fixing the teeth with wire.

Fractures of the bones of the nose are treated by raising the depressed fragments by means of an elevator. If there is extensive

hemorrhage, the nose is packed and the packing left not longer than 24 hours. Compound fractures of the nose are treated by excision of the ragged edges and by primary closure of the skin. The wound is left without any dressing.

Fractures of the lower jaw with displacement are treated by fixing the neighboring teeth of the fragments together. Then the patients are sent to a jaw surgeon or to a dentist for a suitable prothesis.

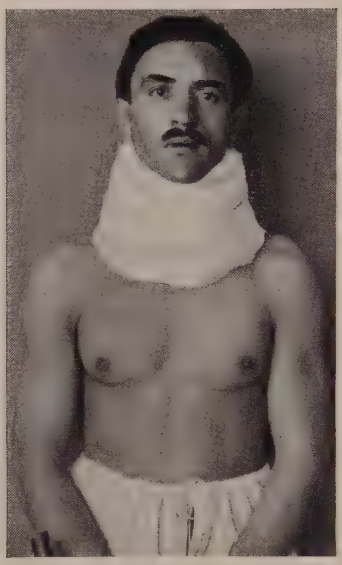


Fig. 82

Fig. 83

Fig. 82. A collar support (Schanz) used for the treatment of fractures of the base of the skull and also of fractures of the cervical vertebra.

Fig. 83. A plaster jacket used for the after-treatment of fractures of the dorsal and lumbar vertebrae.

FRACTURES OF THE SPINE

The vertebral column has a double function; on the one side it protects the spinal cord, and on the other side, it supports the trunk. The kind of treatment varies, depending on whether the spinal cord is injured, or the static of the vertebral column is disturbed.

Fractures of the Body of the Vertebra with Injury to the Spinal Cord

The spinal cord may be crushed or torn through by a pronounced displacement of the body of the vertebra, or by the pressure of a broken arch; it can also be injured by pressure from a blood clot. Cases with complete tears in the spinal cord cannot be healed; it is different, however, if the injury has been caused by pressure. A carefully performed lumbar puncture can reduce the pressure which is caused by the accumulation

of blood. Displaced fragments can be partially or even completely reduced if continuous extension is exerted. The patient is laid on a firm and even bed which sinks down in no place (boards between the spring mattress and the firm hair mattress, see page 30, Fig. 84). A Glisson sling is applied and fastened to the head of the bed and not over a pulley. The head of the bed is raised 50 to 70 cm. A flat pillow is placed under the fracture in order to reduce the kyphosis. The patient is now hanging on his head and the weight of the body forms the counter-extension. The traction by means of adhesive plaster or a cuff attached to the thigh, is dangerous because pressure sores may easily occur on the anaesthetic skin. The pelvis is supported by a water pillow and cotton rings are introduced under the heels. The extremities are

Fig. 84

Fractures of the vertebra treated by Glisson's sling.
The head of the bed is raised 50 cm.

protected by a cradle, in order to exclude pressure by the covers. A permanent catheter is introduced and the bladder washed out twice a day with boric acid solution. The patient is given seven grains of urotropin three times a day, and also a cup of bladder tea in the morning and in the evening. (This consists of an effusion of uvae ursi leaves and herba herniariae.) One must avoid every fold or moisture in the bedding. Every morning and evening, the patient must be carefully turned on his side, and the back sponged with alcohol and diluted vinegar.

The very bad cases are best treated in a water bath.

The cases with complete rupture of the spinal cord develop bed sores and an inflammation of the genito-urinary tract, in spite of all precautions.

The paralysis which results from the pressure of a displaced fragment or from a blood clot, disappears in time if the displacement of the

fractured fragment and the kyphosis are reduced, or when the blood clot is absorbed. These cases are then treated like those which do not show any paralysis from the beginning.

Fractures of the Vertebral Arch with Symptoms of Paralysis

It is seldom that the arch alone of a vertebra is fractured, showing a displacement towards the spinal canal. These fractures should be very exactly determined by X-Ray examination. A laminectomy offers a good prognosis in these cases, provided that the displaced fragment only presses on the spinal cord but does not crush it.

Fractures of the Body of the Vertebra without Paralysis

In fractures of a spinal column from compression, one finds that one or several bodies of the vertebrae are fractured by being pressed together; the deformity is either transverse or, what is more common, wedge-shaped. This gives rise to a traumatic kyphosis and a serious disturbance in the static of the spine. The aim of the treatment is to reduce the crushed body of the vertebra, and to hold it in good position until firm union takes place.

Fig. 85
A plaster shell prepared for the treatment of fractures of the vertebra.

On account of the nature of the spinal cord, it is impossible to reduce the fragments of the body of the vertebra by forcible means. It is, however, possible partially or completely to reduce the fractured vertebrae by continuous traction and by a satisfactory position in a plaster of Paris shell. The patient is placed on a firm bed in the same manner as in fractures with paralysis. His head is fastened to the head of the bed by means of a Glisson sling and the bed raised 50 to 70 cm. (Fig. 84). No pulleys are used. A flat pillow is introduced under the site of the fracture. On account of the fact that the pillow often slips out of its place, the patient is placed on a *plaster of Paris shell* a few days after the accident (Fig. 85). The plaster bed is made in the following manner. The patient is placed on a flat table with the abdomen facing down. The hands are hanging down and paddings are provided for the forehead and for the groins. The head and the back are covered with a thin cloth and over this, the dorsal surface, from the head to the buttocks, is covered by plaster of Paris splints, which include the whole of its longitudinal and transverse extent. The plaster must be

well and carefully moulded. As soon as the plaster becomes hard the shell is removed, properly fashioned by cutting out the redundant parts, and dried. The part covering the neck breaks very easily, and it is therefore reinforced by adding a strong iron rod. For this purpose we employ an iron such as is used for the walking heel (Fig. 64). After 24 to 48 hours, the patient is placed in the plaster shell, which has previously been padded with soft flannel. Under the site of the fracture, a cotton pad 10 × 10 cm. is applied and changed daily. In this way, we are able to reduce the kyphosis in the same manner as is practiced in Pott's Disease.

The patient remains in the shell for about four to twelve weeks, depending on the degree and extent of the injury. He is then given a plaster jacket and finally, an orthopaedic support, which the patient is able to change daily. If, in the more serious cases, the immobilization is removed too early, the kyphosis may increase and paralysis may result.

If the shape of the body of the vertebra is only a little changed, it is sufficient to treat the patient by simply placing him on a firm bed without extension and without a plaster shell. After two to four weeks, he is given an orthopaedic jacket.

Fractures of the cervical vertebrae are first treated by a collar splint made from cotton, suggested by Schanz (Fig. 82) and later they are given an orthopaedic appliance for the neck.

If, after a year, the patient's complaints are not relieved, a good result can be obtained by transplanting a part of the tibia into the vertebral spines over the fracture site, as suggested by Albee.

Fractures of the Transverse and Spinous Processes

These cases are treated by rest in bed for one to three weeks. The complaints often completely disappear after six to eight weeks. Fracture of the transverse process of the fifth lumbar verteb mraay, however, be very troublesome. In these cases, as well as in the fractures of the spinous process, the removal of the fragments is indicated, because they heal only by connective tissue, and because they are painful.

FRACTURES OF THE RIBS

Fractures of the ribs are, in themselves, harmless. It is only the complications with injury to the pleura, lungs or heart, which are dangerous.

The immobilization is much more important on account of injury to the pleura and to the lungs, than to the bones. On account of the respiratory movements, especially during coughing, the patient experiences a great deal of pain and therefore attempts to suppress deep breathing and coughing. This may give rise to inflammatory conditions of the lungs, or to disturbances of the heart action. By using adhesive plaster,

it is possible to alleviate the pains considerably or to make them disappear altogether. During coughing, the chest cannot suddenly expand now, thereby preventing irritation at the site of the fracture and of the pleura. The patient is first directed to take a deep breath; and then an adhesive plaster, 10 cm. wide, is wrapped around the whole circumference of the chest during expiration. The plaster must always be applied in the lower part of the chest, even if the fracture is in the upper ribs, because the greatest mobility is in the lower part. If the upper ribs are fractured, an additional strip of adhesive plaster is placed over the shoulder (Figs. 86, 87), because in raising the arm, the muscles of the shoulder and the muscles about the thorax, pull on the fractured fragments. One can also use elastic bandages, but these have a disadvantage because they easily slip and must be constantly renewed. Strips of adhesive plaster applied only to the fracture site are useless. On the first day, morphine should always be given and later, if there is coughing, codein should be given for the night. The adhesive plaster is left on for three to five weeks, dependent upon the degree of injury. In order to prevent *post-traumatic bronchitis*, we employ injections of ether. This was suggested by Bier for the treatment of bronchitis coming on after ether anaesthesia. We give 1 cc. of a mixture of ether in olive oil daily. We have found this treatment beneficial also in serious crushing injuries of the chest without fracture of the ribs. Before this treatment was applied, these cases developed a putrid bronchitis in the first days after admission, during the winter months. But at the present time, this complication rarely occurs.

Fig 86 Fig. 87

Fig. 86. An adhesive girdle surrounding the whole chest used for fractures of the lower ribs.

Fig. 87. Fractures of the upper ribs are treated in the same way, with the addition of a plaster strip over the shoulder.

The *emphysema of the skin* which results from a concomitant injury of the lungs and pleura, does not require any particular treatment. It disappears of itself after a few days or at the most, after two weeks.

A *pneumothorax with much tension* can be relieved by a puncture, with suction of the air.

Hemorrhages into the chest cavity can be relieved by aspiration. This, however, should only be done five or six days after the injury, since otherwise a new hemorrhage is apt to take place.

Compound fractures of the ribs are treated in the same manner as the other compound fractures. The wound is excised and the skin

completely closed. If the chest has been opened, it is particularly important to close the wound completely so as to avoid mediastinal flutter and also infection. If infection has already taken place, the pus is removed with a trocar and the case treated in the same manner as an empyema.

FRACTURES OF THE STERNUM

Fractures of the sternum without any displacements, are treated by strapping the chest with adhesive plaster—the same as in the fractures of the ribs. If there are any displacements and if shortening is present, the fracture can be treated by continuous extension with the use of Glisson's sling, and also by the introduction of a wide, hard pillow under the chest.

FRACTURES OF THE PELVIS

Fractures of the Pelvic Brim

Fractures of the iliac fossa without displacements, are treated by rest in bed for two or three weeks; if there are any displacements, a circular bandage is applied. These fractures always heal without leaving any serious disturbances.

Fractures of the anterior superior spine which show a considerable displacement downwards on account of the muscle pull, can be reduced by an open operation, performed about a week after the injury.

Fractures of the lower end of the sacrum are quite uncommon. They are treated by a rest in bed for several weeks.

Fractures of the coccyx may occasionally cause long-lasting disturbances. If the tenderness on pressure persists, it is better to remove the coccyx.

Fractures of the Acetabulum

Fractures of the floor of the acetabulum and of the ridge without any displacements, are treated by weight extension for four to six weeks in the same manner as in fractures of the femur. If the head of the femur penetrates through the acetabulum into the pelvis (the so-called central dislocation of the hip-joint), it must be reduced by a powerful pull. Occasionally one succeeds in bringing out the head from the pelvis by using weight extension, and by elevating the foot of the bed. It is, however, advisable to use the screw traction apparatus.

In order to treat a central dislocation of the hip, the following is needed:

(1) A screw traction apparatus used for the lower extremity (Fig. 38).
(2) A rustless nail with a U-shaped tractor or ice-tongs.
(3) Hegar's dilators or a diathermy electrode for the rectum.
(4) Spinal anaesthesia, see page 18 (Fig. 15).

The reduction is performed under spinal anaesthesia. The patient is placed on the screw traction apparatus, and a nail or the ice-tongs introduced above the knee-joint. An assistant pulls forcibly on the normal leg (Fig. 158) and the surgeon turns the screw of the apparatus thus bringing the head of the femur out of the pelvis. A rectal examination is now made, in order to ascertain if there are any bone splinters protruding into the pelvis. If this happens to be the case, an attempt is made to press the fragments back with the finger and if not successful, an electrode is introduced and the fragments pressed into place. The patient is then put to bed with the extremity resting on Braun's splint and treated in the same manner as for fractures of the femur, see page 110. By using correspondingly heavy weights, the head is prevented from slipping into the pelvis again; the floor of the acetabulum heals in good position. The patients are able to sit up from the beginning. The hip-joint is therefore moved to a considerable extent and no stiffness takes place (Fig. 143).

In fractures of the acetabulum, the weight extension is left on for six weeks, provided there are no displacements. In the central dislocation of the head, the weight extension is left on for eight to twelve weeks, depending upon the depth of the dislocation. After three weeks, the nail is removed and the extension maintained by a zinc-gelatin dressing (see page 120).

Fractures of the Pelvic Girdle

While fractures of the pelvic brim are in most cases harmless, those of the pelvic girdle can produce very serious complications, and be even dangerous to life. The urethra is most commonly injured, the bladder not so commonly and the intestines still more rarely. The injury of the nerve roots, and the disturbed static of the skeleton due to these fractures, are apt to leave permanent disabilities.

Every fracture of the pelvis must be examined for a possible injury of the *urethra*. A drop of blood at the meatus speaks, in most of the cases, for an injury of the urethra. If no blood is seen, the urethra is pressed and milked from the perineum forward. If blood is present, it may come either from a tear in the mucosa or from a complete tear of the urethra; it may also come from the bladder or from the kidneys. If an injury of the uro-genital tract is suspected, a soft Nelaton catheter must be introduced into the urethra and the bladder. If, after a few drops of blood, the urine comes out clear, it indicates that there is only a superficial injury of the mucous membrane of the urethra. If, on the other hand, the urethra is completely torn through, it is impossible to introduce the catheter into the bladder. Only blood which originates at the site of the injury, comes out of the catheter. Occasionally a few drops of fat, which originate from the broken os pubis, are seen to float in the blood. One may also feel the catheter rolling on

itself in the perineum. The butterfly-shaped extravasation of blood, which surrounds the anus only appears 5 or 6 hours after the injury.

If an *intraperitoneal rupture of the bladder* has taken place, the amount of urine obtained by the catheter is usually only a few drops; it is either of a light-red color or clear. This is particularly striking if the patient relates that he has not passed any urine for several hours, in spite of having taken a lot of fluid. If the abdominal wall is tense and if, after introducing a hundred to two hundred cubic centimeters of boric acid solution into the bladder, nothing can be drained back, the diagnosis of a rupture of the bladder is definitely established.

The signs and symptoms of extraperitoneal rupture of the bladder, are the same, only it seems that in the latter cases there is usually more bleeding. If much blood or urine is obtained from the catheter, it comes as a rule from the kidney. In these cases, one also finds tenderness over the kidney.

The Treatment of Injuries of the Urethra, Bladder and Kidney

All the injuries of the genito-urinary tract are best operated under spinal anaesthesia (see page 16). Any other form of local anaesthesia is not always sufficient because the posterior part of the pelvic girdle is frequently also fractured, and the patient is unable to lie on his back on account of pain. General anaesthesia, especially if there is also an injury to the ribs and lungs, is dangerous.

The patient is placed on his side and the perineum and the pubes well shaved. A soft catheter is then introduced into the urethra and exposed by a transverse incision under the base of the scrotum. We no longer employ the longitudinal incision because it is too near the anus and can therefore become easily infected. After opening the skin, the muscles are separated in the mid-line by using the finger or a dull instrument. Now one encounters an irregular cavity filled with blood and the catheter which has been introduced into the urethra. First, the blood is sponged away and the bleeding points ligated. The central end of the urethra is now looked for. Occasionally the latter is easily found in the wound, and at other times it is more difficult to find it. We have always succeeded in locating the central end of the torn urethra. If this should not be possible, the bladder must be opened by a supra-pubic incision and a catheter introduced into the urethra from the inside of the bladder. Immediately after the central end of the urethra is found, the catheter, which has been placed in the peripheral part of the urethra, is now introduced into the bladder through the central part. The catheter must be syringed out with boric acid solution, because the blood clots very easily and prevents the outflow of urine from the bladder. After the catheter has been introduced into the bladder, the torn ends of the urethra are sutured over the catheter, using very fine catgut. The muscles and the skin are closed, using closely placed interrupted sutures but no

drainage of any kind. This is particularly important, since the introduction of any form of drainage, leads usually to an infection. This is frequently followed also by osteomyelitis of the pelvic bones or by an infiltration of urine. Even if the infection is only slight, the sutures give way and a fistula and scar formation take place, giving rise to a stubborn stricture of the urethra. If, on the other hand, the urethra and the skin are exactly and completely closed, the wound heals without any infection, and we are thus able to avoid its bad consequences.

The catheter is left in place for two weeks, and the bladder irrigated morning and evening with boric acid solution. After fourteen days, the catheter is carefully changed and a week later it is removed entirely.

Of the ten cases treated in this manner, three died. One of these developed osteomyelitis of the pelvic bones and a lung abscess; the second one also developed an osteomyelitis of the pelvic bones and a metastatic infection of a hematoma, which was the result of a concomitant fracture of the femur. The third patient died a few hours after admission, on account of serious injuries all over the body.

In the first case, in addition to the fracture of the pelvic girdle and tear of the urethra, there were also a compound fracture of the femur and fractures of numerous ribs with injury to the pleura and the lung. The cause of death in this case was chiefly due to the lung abscess.

In the second case, the patient had a torn urethra and a dislocation of the symphysis, and also a dislocation of the sacro-iliac joint. There was also a fracture of the femur. An infection took place in this case because a longitudinal incision was used; the latter was retracted with a hook, which tore into the anus.

In all the other seven cases, the wounds healed by primary union. The patients had not the slightest difficulty in passing their urine. The follow-up examination showed that the urethra was of normal width.

Injuries of the bladder are treated by exposing the latter with a suprapubic incision. If the apex is torn, the peritoneum is opened and the bladder examined through the tear; the latter is closed by using a double row of sutures. If the tear is extra-peritoneal only, the peritoneum should not be opened. The wound in the bladder is carefully closed. If the injury is in the neighborhood of the ureter, one must be careful not to include the opening of the latter in the suture. After the wound in the bladder is repaired, the skin is completely closed, without any drainage. Injuries of the bladder are frequently accompanied by extensive hematomas which fill the small pelvis. The latter would, in all probability, become infected if the skin were not completely closed. No catheter is introduced in the bladder. If the urine is cloudy, the bladder is carefully irrigated in the morning and in the evening. One should be very careful not to use more than 50 to 60 cc. of the solution at one time.

Injuries of the kidney are treated conservatively in most of the cases. The blood-colored urine usually disappears in a few days.

If extra-peritoneal ruptures of the bladder and the urethra are not quickly operated on, *an infiltration of urine* into the surrounding tissues soon takes place, and the patient dies from septicemia. Extensive incisions are sometimes able to save the patient.

The ruptures of the bladder into the peritoneal cavity, if not operated immediately after the accident, lead to fatal peritonitis.

Injuries of the rectum are exposed by an adequate incision and the wounds closed. After the operation the skin incision is left open. The sphincter is dilated in order to facilitate the escape of flatus.

Injuries of the small intestine are very rare. The wounds must be closed in the usual accepted manner.

Treatment of Fractures of the Pelvic Girdle

The lateral fragments in isolated fractures of the anterior or posterior sides of the pelvic girdle and also the longitudinal fractures, are displaced towards the mid-line and pulled upwards. These displacements are brought about by the pull of the ileo-psoas, the muscles of the abdominal wall, the gluteus maximus, the small muscles between the pelvis and the femur, and also by the adductor muscles. The fragments can be reduced by exerting an adequate, powerful pull on the lower extremities.

The patient is placed in bed with the lower extremity corresponding to the injured side of the pelvis on a Braun splint. Weight extension is instituted by introducing a nail through the tuberosity of the tibia. (For technique, see page 110, Figs. 130–144.) The pull on the extremity does not only serve to reduce the fractured fragments but also keeps the patient free from pain. The patient is also able to move, and as a result, bed sores and lung and heart complications are avoided. If, on the other hand, only a circular bandage around the pelvis is used, the latter may occasionally press the fragments more against each other, but the heavy extremity still hangs on the fractured half of the pelvis. With this arrangement, all movements are impossible. If both sides of the pelvis are fractured, both extremities are placed on Braun's splints and a pull exerted in the same manner as in the fractures of both femurs (Fig. 156). In the rarer cases where the fragments are widely separated a circular bandage is applied in addition to the longitudinal pull.

The weight extension is left for six to eight weeks, dependent upon the degree and extent of injury. The nail is taken out after three weeks and substituted by a zinc-gelatine extension dressing.

FRACTURES OF THE CLAVICLE

In fractures of the clavicle, the central fragment points backwards and upwards on account of the pull of the sternocleidomastoid muscle. The peripheral fragment is sunken down anteriorly and medially, partially

by the weight of the arm, and partially by the pull of the scapula and the muscles running between the thorax and the humerus. In order to bring the peripheral fragment in the axis of the central one, the shoulder is raised upwards and posteriorly. The shortening can be corrected by a longitudinal pull which engages the whole shoulder and which is directed not only backwards but also laterally. The pull posteriorly is necessary, because the shortening is not due to the pull of the pectoralis major and minor and the subclavius muscles only, but also to the pull of the adductors on the posterior aspect such as the trapezius, the levator scapulae, rhomboideus major and minor and latissimus dorsi, which take origin on the dorsal surface of the trunk.

There are over one hundred different kinds of bandages suggested for the treatment of these fractures. By the use of a Desault bandage with an adequate pillow in the axilla, we are able to displace the whole shoulder laterally. In this form of treatment the shoulder-joint is left completely immobilized and therefore leads to joint stiffness in older individuals. In the treatment suggested by Bardenheuer, in which the arm is extended backwards and upwards, the adductors of the shoulder-joint are put in extreme tension and therefore offer a powerful resistance against the correction of the fragments in the longitudinal axis. In Sayre's bandage only the anterior adductor muscles are considered and the shoulder is placed near the trunk. All various bandages similar to Sayre's could be effective only if the scapula were firmly attached to the trunk.

The angular deformity can be corrected by raising the shoulder-joint and thereby also the peripheral fragment. The shortening and the lateral displacement is reduced by a longitudinal pull in the direction of the axis of the clavicle. The setting of the fracture could be accomplished, by putting the knee of the surgeon between the patient's shoulder blades and pulling the shoulders backwards, powerfully with both hands, the patient meanwhile assuming a sitting position. We can accomplish the same by placing a fist in the axilla and with the other hand, pressing the patient's elbow against the trunk over this resistance. It is very difficult, however, to maintain the raised position of the shoulder. With the various methods of bandaging, such as Velpeau, Desault, Sayre and others, we cannot usually secure a lengthening but, on the contrary, we get an overriding of the fragments. The extension bandage advised by Bardenheuer with the arm abducted and elevated is not able to reduce the shortening, since it increases the tension of the muscles which bring about the displacement of the fragments, instead of relaxing them.

A bandage, in order to fulfill the requirements for the rational treatment of this fracture, must pull the whole shoulder with the arm adducted, away from the trunk, and at the same time, also raise the shoulder. There should be no injurious pressure on the nerves or blood vessels, and the joints of the arm should be completely free.

The seat of the fracture is made painless by the injection of a 2% novocaine solution. We need only a short needle since the fracture is

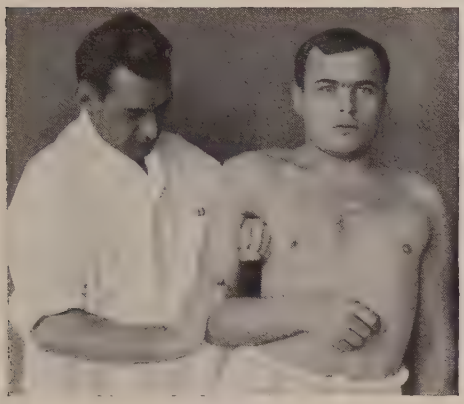


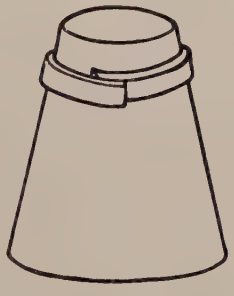
Fig. 88 Fig. 89 Fig. 90

Fig. 88. The setting of a fracture of the clavicle.

Fig. 89. A clavicle splint applied in a dislocation of the medial joint.

Fig. 90. A clavicle splint applied for fracture and dislocation of the clavicle at the peripheral end. On account of the ambulatory treatment, the part used for the forearm to rest upon, has been removed one week after the accident.

very superficial. With one fist in the axilla, the shoulder is raised and with the other hand the elbow of the patient is grasped and pressed against the trunk. This manœuvre pulls the shoulder away from the body and reduces the shortening (Fig. 88). The clavicle splint is now ready to be applied. The main part of this splint consists of a board which is 30 cm. long, 15 cm. wide and 5 cm. thick, the part fitting into the axilla is smoothed into a Gothic arch in order to fit the concavity of the axilla. The splint is introduced between the arm and the trunk. Another board $40 \times 16 \times 1$ cm. is attached at a right angle to the main part and is used for the support of the forearm. Two iron ribbons, $50 \times 4 \times 0{\cdot}4$ cm., with two short belts, are fastened to the main part of the splint and are used to fasten the splint against the trunk. A third belt attached to the splint is fastened over the



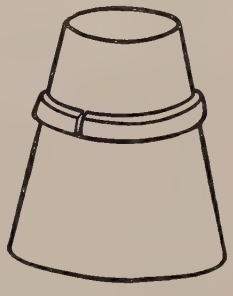


Fig. 91 Fig. 92

Fig. 91. The chest is like a truncated cone and the fractured clavicle corresponds to a part of a broken ring.

Fig. 92. If the shoulder girdle is not only pulled backwards but also downwards, the shortening of a fractured clavicle can be reduced in the same way as a broken ring pulled over a truncated cone or a barrel.

normal shoulder and is used to raise the injured shoulder. A fourth belt with a buckle is introduced under the lower iron ribbon and is used to press the medial fragment down.

The part of the splint which is next to the trunk and the iron ribbons, must all be well padded. Slender pillows are also placed over the normal shoulder and under both of the transverse belts. After the splint is applied, we again examine the position of the fragments. If there is still a shortening present, more padding is applied over the splint in the axilla and the shoulder raised higher. The medial fragment is pressed downwards by an adequate belt over the shoulder. This belt is necessary to keep the medial fragment in its place, because it is influenced by the sternocleidomastoid muscle and is therefore raised when the head moves. An X-Ray picture is now taken to control the position of the fragments.

If the splint is properly applied, the fragments remain in their position and the joints of the arm are free. The elbow, the hand and the fingers can be used at once. During the first week the shoulder-joint can be raised only to the horizontal plane, while during the second week, the movements of the shoulder-joint are completely free. The patient can at once perform light work. I saw one patient play the piano on the second day following the fracture. In this way, atrophy of muscles and stiffness of joints can be avoided. If there is pressure in the axilla against the blood vessels and nerves and the patient begins to feel that his fingers are tingling, all he needs to do is to raise his arm and at once release the pressure. In many of the older forms of immobilization and particularly in the methods suggested by Desault, a wedge was introduced in the axilla and the elbow pressed against the chest in order to pull the fragments apart. This form of bandaging, however, produces much pressure on the blood vessels and the nerves. The arm swells and frequently paralysis of the whole arm, and in some cases, even gangrene of the fingers is observed. If this form of bandage is left on for a long time, stiffening of the joints takes place, the chest is restricted in its movements and eczema takes place in the axilla on account of the retention of sweat.

If a ready-made splint is not at hand, one can improvise one by using sheet wadding or cotton and placing it in the axilla which has previously been powdered. The padding in the axilla is fastened over the normal shoulder. This bandage becomes loose and should be renewed every fourth or fifth day.

If one uses a figure-of-eight bandage, it is important that it should be pulled upon by a perineal belt, because otherwise the shoulders would give way upwards and inwards. We can consider the chest as a cone-shaped body with the shoulder and the broken clavicle as a ring. The deeper the ring is pulled against this cone, the more the fragments of the broken clavicle recede from each other (Figs. 91, 92).

The splint is left on for three weeks if there are only angular deformities. In complete displacements of the fragments and in splintered fractures, the bandage is left on for four to five weeks, in rare cases longer. If the splint is removed before firm union takes place, the fragments are apt to become displaced again.

If this form of clavicle splint is used, the joints remain free and the muscles remain powerful. Consequently, after-treatment is not necessary. In order to strengthen the muscles, we direct the patient from the first week to exercise on the pulley.

FRACTURES OF THE SCAPULA

In fractures of the body of the scapula, as well as in those of the neck, we see that the lateral and upper fragment sinks down from the weight of the arm and from the downward pull by the muscles attached between the chest and the arm. For the reduction of this fracture, we also use local anaesthesia. The fracture is reduced by abducting the arm with a powerful pull outwards. The arm is then placed on an aeroplane splint and treated in the same manner as in fractures of the humerus. The splint is carried about four weeks.

Fractures of the acromion process can be treated either by the aeroplane splint, or by the use of the clavicle splint.

FRACTURES OF THE HUMERUS

Fractures of the Upper End of the Humerus

In the adduction fractures with pronounced displacement we find that the upper fragment is abducted and outwardly rotated, the lower fragment is adducted, bent backwards and also inwardly rotated and displaced inwards and anteriorly. The axial deformity in the sagittal plane which forms an open angle facing posteriorly is corrected by raising the arm lightly forward. The angular deformity in the frontal plane is corrected by raising the arm laterally to a right angle. The arm is now rotated outwardly 90° with the elbow at a right angle, in order to reduce the rotation displacement. The shortening is reduced by a longitudinal pull and after this is accomplished, the central fragment which is abducted, usually snaps into its place by itself or can be reduced by light pressure. We could never reduce this fracture if we pull in the longitudinal axis of the body, because the shorter central fragment does not follow the distal one and because the tendon of the biceps is often interposed between the fragments. The lower fragment must be placed where the upper one points. This can be accomplished if we raise the arm laterally and rotate it about 90°, and then bring it 30–40° in front of the frontal plane. This is the mid-position of the arm in relation to the shoulder and to the body. The arm can normally be

moved 180° laterally and 180° forward. For this reason, raising the extended arm lateralwards and forwards with the elbow flexed at a right angle to about 90° signifies a mid-position. In the third plane of space, the horizontal, we can normally move the arm 30° posterior to the frontal plane and 120° anterior to the frontal plane. The middle position of the arm is therefore 45° in front of the frontal plane and not in the frontal plane itself as Zuppinger assumed it to be.

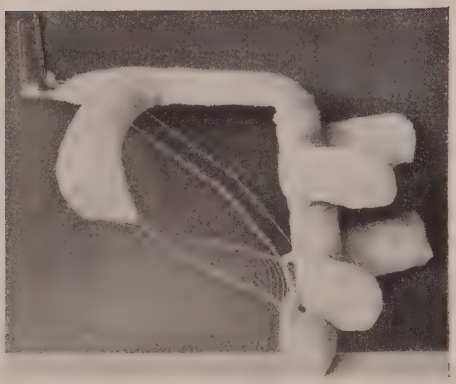


Fig. 93
A well padded abduction splint made of Cramer's wire splinting.

The mid-position of the arm in relation to a firmly held scapula is accomplished if we raise the arm laterally and forwards, and at the same time, rotate it outwards to about 45°. This position, however, has no significance from a practical point of view, because in every attempt to raise and to rotate the arm, the scapula also moves. The mid-position of the shoulder-joint is not only the most favorable for the reduction of the fracture, but also for the muscles because they are placed in moderate tension and are therefore subject to the least degree of atrophy. If the arm is placed in an extended position and outwardly rotated, it forces all the muscles about the joint in an extreme position. The subscapularis is shortened to a maximum degree, and because it is also permeated by an extravasation of blood, it very soon becomes shrunken. The deltoid, the supra- and infraspinatus and the teres minor are stretched to a maximum and therefore rapidly become atrophic. The mid-position is also the most favorable for the circulation, because the blood flows in the horizontal plane, if the patient is either standing or sitting. If the patient is recumbent, the forearm is in the upright position allowing the veins to empty downwards. The nerves are also in a relaxed position.

Fig. 94
Adhesive plaster strip cut at both extremities and provided with a little board and a string. Both ends are fastened to wooden tongue depressors in order to prevent the rolling up of the adhesive.

For the treatment of a fracture of the humerus the following items are needed:

(1) A well padded abduction splint made of wood, aluminium or Cramer wire splinting (Fig. 93).

(2) An adhesive strip 80 × 6 cm. with a board 6 × 8 cm. in the middle, and attached to a string (Fig. 94).
(3) Three cushions 50 cm. long by 10 cm. wide.
(4) Three gauze bandages 10 × 15 cm.
(5) A starch bandage 10 × 15 cm.
(6) Local anaesthesia, see page 16 (Fig. 15).

First the patient is examined and particular attention is paid to the possible injury of nerves or blood vessels. An X-Ray picture is then taken to determine the exact condition of the fracture. 20 cc. of a 2% novocaine solution is injected between the fragments and the arm placed on the padded splint (Figs. 49–51; 93).

The padding of the wire splint must be so made that the surface is convex. The concave surfaces of the splint, which are directed against the chest, the arm and the forearm, are first filled with thick round padding made of cotton or sheet wadding and then covered by longitudinal strips of the same material so as to cover the edges of the wire splint.

The exact fixation of this splint is technically very difficult, and at the same time, of the greatest importance. For the exact fixation of this aeroplane splint made of wire, we need three gauze bandages 10 × 15 cm. and also a starch bandage 10 × 15 cm. to cover the gauze bandages.

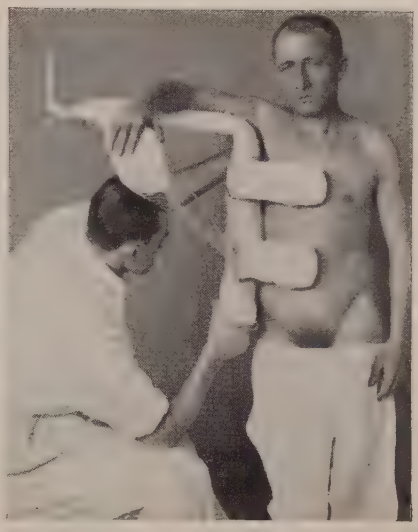


Fig. 95
During the application of the abduction splint, the latter must be continuously held by an assistant and pushed against the axilla.

The splint must always be placed in its proper position before the fracture is reduced. The assistant holds the splint against the patient's body pushing it firmly upwards against the axilla, and takes care that the part of the splint for the upper arm is 30–45° anterior to the frontal plane. A cushion is placed over the normal shoulder. The first bandage is wound around the chest and the abdomen not loosely, but, on the other hand, not so tightly as to embarrass respiration. The second and third bandages are wound alternately around the chest, abdomen, and over the normal shoulder. All turns which pass over the shoulder, must come from under the lower edge of the splint next to the chest. The turns which come from under the lower edge of the splint must also be taken once around the splint itself in order to prevent the slipping of the latter backwards or forwards. A splint applied in this way can remain two or three months without showing any displacement. Some surgeons only use one bandage for the fastening of the splint. This,

however, is not sufficient, since the splint becomes displaced in a few hours and with it also the fragments. The patient suffers great pains and can not sleep. He walks fearfully supporting the lower end of the splint with his normal hand and pushes it upward on account of its tendency to sink. It is for this reason that many declare that carrying an aeroplane splint is a torment for the patient. I have used this form of splint in more than two thousand cases; it was therefore carried by patients for about 40,000 days and most of the patients considered it comfortable.

After the splint is properly placed, the adhesive plaster is now applied. An adhesive band is divided into three parts at each end. That part of the adhesive plaster which is divided is placed a hand-breadth above the elbow. The outside of the adhesive and the skin is painted with Mastisol and fastened with gauze bandage. The assistant now exerts a pull in the longitudinal direction with the forearm at a right angle. In *adduction* fractures, the position of the arm on the aeroplane splint, reduces spontaneously the angular deformities in the frontal and in the sagittal planes and also the outward rotation. In *abduction* fractures, the arm is first vertically raised and a fist placed in the axilla. By sinking the arm downwards and by a concomitant pull, we can reduce the abduction angle over the fist as over a wedge. The shortening disappears on account of the longitudinal pull by the assistant and then the fragment snaps into place from its lateral position either spontaneously or from pressure with the finger. If the shortening is quite pronounced, the assistant places his foot on the splint against the axilla in order to exert a more powerful pull. After the fracture is reduced, an extension string, drawing on the adhesive traction band, is attached to the vertical part on the end of the wire splint. The wire splint vibrates easily and therefore exerts an elastic pull. In the ready-prepared aeroplane splints, which are made of wood or aluminium, the string is passed over two pulleys and is then attached to a spring (Fig. 101).

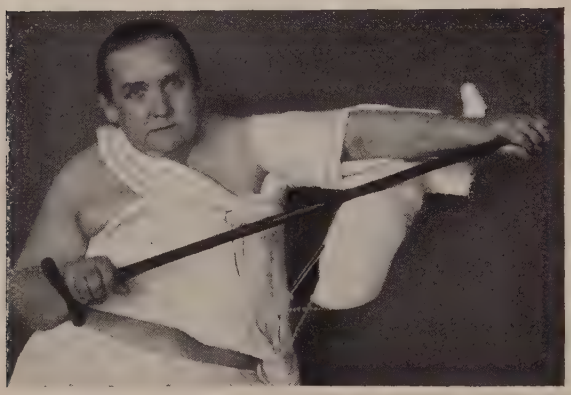


Fig. 96

Sixty-four year old woman with a fracture through the surgical neck of the humerus, with the arm under traction on the abduction splint, making stretching exercises of the arm.

If the fracture is first reduced and the arm then placed on a splint, a new displacement is apt to take place again. The proper application of this splint is particularly difficult and often quite impossible in

For humerus - fix Crama first.

anaesthetized patients. This is the reason why many were unable to obtain an exact reduction of these fractures and therefore demanded an open operation.

The post-operative treatment can be started at once. The movement of the hand, the finger-joints, and the forearm are at once free and active. The elbow can be moved passively in a horizontal plane with the help of a cane manipulated by the normal hand. The use of the cane is necessary also in order to prevent the hand of the injured extremity from falling off the forearm part of the splint, and therefore preventing a rotation displacement of the fragments. In a few days, the movements of the elbow-joint become free and active. Some patients are able to move the elbow-joint actively immediately. One must pay particular attention from the beginning that the elbow is extended to its full range. It can be easily observed that if the elbow is moved actively and the hand forcefully flexed or extended, the muscles of the immobilized shoulder are also contracted. As soon as the patient is able to move his elbow actively, he is directed to exercise on the pulleys. With this form of treatment, oedema of the forearm or of the hand is never seen and if a swelling has already been present, it disappears the day after the arm has been placed on an aeroplane splint. After a few weeks the traction is temporarily discontinued and the patient allowed to make lateral movements of the arm with the aid of a cane. After four weeks, rotation movements of the shoulder-joint are started; the patient is directed to place the hand behind the head and also on the normal shoulder. If after such exercises, no more pain is experienced, the extension dressing can be removed. The abduction splint is, however, left on until the patient is able actively to move the arm 140° lateralwards with the elbow extended. In this case, the aeroplane splint is still left on for a week longer in younger individuals and for two weeks longer in the older ones. During all this time, the patients must exercise five to six times a day by pulling the weights twenty times over horizontal and vertical pulleys at each exercise, also by placing the hand of the injured arm behind the head, by letting the arm hang down in front of the splint next to the body, and also by touching the normal shoulder with

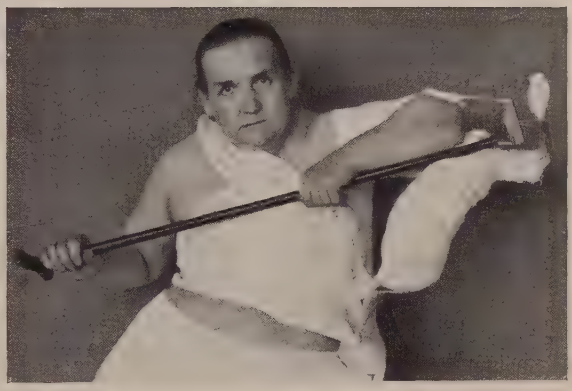


Fig. 97

Flexion of the elbow. The fingers and the hand are not swollen; all the joints are free.

the hand. If the patients are complaining of pain, baking and diathermy are used.

If the splint is removed too early, the active raising of the arm laterally and the rotation of the shoulder are, on the following day, no more possible.

Fractures of the Humerus complicated by Dislocation of the Shoulder-Joint

If the humerus is not only broken but the head dislocated also, it is impossible to place the head in its proper position by using the procedure described by Kocher. First the humerus with the arm placed in mid-position, must be pulled away exerting considerable force, from the anterior and inferior edge of the glenoid cavity; in this way plenty of room is obtained for the head of the humerus which can be brought into its place by pressure with the fingers. The surest way to reduce this fracture, however, is by the use of the screw traction apparatus. The following items are needed for this procedure:

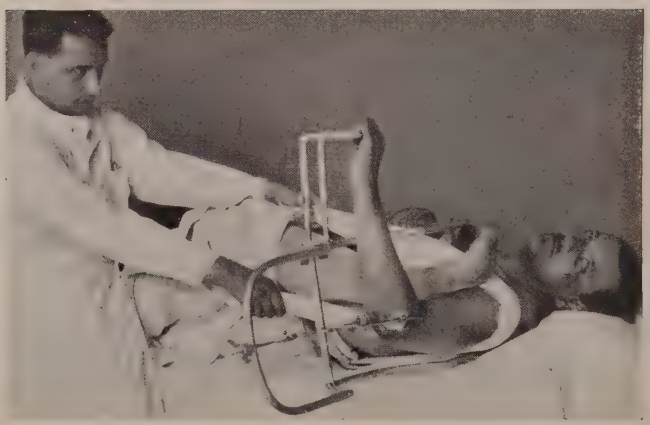


Fig. 98

The reduction of a difficult fracture-dislocation of the shoulder joint with the use of local anaesthesia. The arm is fixed in the screw traction apparatus and a pull applied on the nail introduced through the olecranon. The acromion is then covered by a sling and the head which is displaced downwards is pushed into the joint cavity by means of the operator's heel.

(1) 1 screw traction apparatus for the arm (Fig. 41).
(2) 1 rustless nail with the U-shaped tractor (Fig. 56).
(3) 1 hammer (Fig. 56).
(4) For further treatment we need an aeroplane splint (Figs. 49–51), see page 72.
(5) Local anaesthesia, see page 16 (Fig. 15).

20 to 40 cc. of a 2% novocaine solution are injected between the fragments, and the seat of the fracture and dislocation is rendered free from pain. About 5 cc. of the same solution is injected on each side of the olecranon and the rustless nail driven through. The arm is placed on the screw traction apparatus and the U-shaped tractor is connected with the hook of the screw. The screw is now slowly turned and after the shaft of the humerus is pulled away a sufficient distance

from the glenoid cavity, the head is pushed upward manually or with the heel in the axilla (Fig. 98). In this way we have always succeeded in reducing these fracture dislocations without resorting to an open operation. The pull by means of the screw is much better than by the use of the hand, since the pull exerted by the screw is slow and therefore very protective to the tissues. If now the X-Ray control picture shows a good position, the screw traction apparatus is removed and the aeroplane splint applied. The further treatment is the same as in the simple fractures of the humerus.

Fractures of the Tuberosities

Fractures of the greater tuberosity are very frequent. Many of the anterior and sub-glenoid dislocations of the humerus are complicated by this fracture. These are mostly fractures due to a tear, but they also result from direct violence such as a fall on the shoulder. In the latter, the displacement is negligible, while in those arising from a tear the displacement is usually very great. The treatment is simple. The whole arm is raised and outwardly rotated. In this way the arm is brought to the upper fragment; this can be seen very well under the X-Ray screen which shows how the tuberosity is being placed in its proper position. The arm is then placed on an aeroplane splint and if there is much swelling or bleeding into the joint, an extension is also made. The movements can begin at once, the same as in fractures of the neck of the humerus. The abduction exercises in the shoulder-joint can begin one to two weeks after the injury. Here also, the arm is left on the splint until the patient can actively raise it and rotate it outwards. It is not necessary to fix the fragment by an open operation.

If the fragment is not reduced, serious disturbances and arthritis deformans of the shoulder-joint take place.

Fractures of the Shaft of the Humerus

The fractures of the shaft of the humerus are treated in the same way as those of the upper end. In fractures of the upper third, one should pay particular attention that the splint is placed far in front of the frontal plane, because the upper fragment is pulled forwards by the pectoral muscles. Fractures of the middle third are treated by the application of anterior and posterior plaster splints over the adhesive extension dressing. This is important in order to avoid new angular deformities and especially the one with an angle open posteriorly. Fractures below the middle are best treated in the same manner as supracondylar fractures.

Fractures of the Humerus above the Condyles and through the Condyles

In fractures near the elbow irrespective of whether they are produced with the elbow in extension or flexion, the lower fragment is always found in a varus position.

In fractures which occur in children and in juveniles with the arm over-extended, the lower fragment is found posterior to the upper one; while in those which arise from a fall and compression on the flexed elbow, the lower fragment is in front of the upper one. The pull exerted by the muscles maintains this position (Figs. 6–7). All the pronating muscles, which are at the same time also flexors of the elbow, pull the lower fragment in a flexed position. If the forearm is supinated, as prescribed in most of the text books, the pronators become very tense and pull the lower fragment in a varus position. By rotating the forearm in a pronated position the pronators which are also flexors, are relaxed. The varus position, with the angle facing inwards and the flexion deformity with the angle pointing backwards, disappear (Fig. 7). The shortening is reduced by a powerful longitudinal pull and after this disappears, the lateral displacement can be reduced by light pressure.

Fig. 99

The reduction of a supracondylar fracture of the humerus by means of a screw traction apparatus, the pull being exerted by a nail introduced into the olecranon. The forearm is pronated.

The following items are needed for the reduction and treatment of supracondylar fractures:

(1) Aeroplane splint (Figs. 49–51).
(2) 2 or 3 plaster bandages 5 m. × 15 cm.
(3) 1 calico or gauze bandage 10 m. × 12 cm.
(4) An adhesive strip 80×6 cm. with a small board (6×8 cm.) provided with a hole in the middle through which a string is drawn.
(5) Local anaesthesia, see page 16 (Fig. 15).

The fracture is first examined and an X-Ray picture taken. 20 cc. of a 2% novocaine solution are injected between the fragments (see page 16). The arm with the elbow flexed at a right angle is completely rotated inwards and the shortening reduced by a powerful pull. An assistant is directed to hold the arm in the corrected position and a plaster splint 70–75 cm. long is made from a plaster bandage. From one end of the splint, 2 strips 3–4 cm. wide are excised. The splint is now applied on the extensor surface of the hand, the forearm and the arm from the base of the fingers to the shoulder. Two small incisions are made on each side of the splint at the level of the elbow. These two edges of the splint, produced by the incisions, are carefully placed over each other and smoothed out. The two strips of the splint, previously prepared, are placed over the edges in order to strengthen the cast near the elbow. The splint is now surrounded with gauze bandage or a calico bandage

and covered by one or two plaster bandages placed in a circular manner. The assistant must maintain the pull continuously by means of his hand until the cast is sufficiently dry. The arm is then placed on an aeroplane splint and an extension adhesive plaster dressing applied to the plaster over the upper arm. A pull is now exerted on the adhesive tape. The cast applied to the upper arm acts as a shell and the pull exerts its action on the extensor surface of the forearm and the hand; it is distributed over a surface of about 200 to 300 sq. cm. and therefore is not injurious to the skin. If a sling is applied on the forearm under the elbow for traction the surface distribution of the pull is small and pressure sores are easily and quickly apt to take place. The X-Ray picture after the attempt at reduction in most of the cases shows a good position. Should this not be the case, the cast is at once removed and another attempt made to reduce the fracture. The fingers must be carefully observed in the first two days after the reduction. If oedema should take place, the cast must be at once split on its extensor surface. With such position of the arm in the aeroplane splint, swelling of the fingers is quite rare. The cast is not removed and therefore new displacements do not take place. The pull can also be exerted with effect on the cast which has been split open.

Fig. 100

Plaster cast has been applied.

Fig. 101

As soon as the plaster becomes hard, the screw traction apparatus and the nail are removed. The arm is placed on an abduction splint and a pull exerted by a spring attached to adhesive strips which are fastened on the cast.

In special, difficult cases, where the reduction is impossible by the use of the hand, we can employ the screw traction apparatus, see page 33.

This fracture is especially feared on account of Volkmann's ischaemic contracture. The plaster cast is usually blamed for this. As a matter of fact, this complication is due to the bad position of the fragments and also to the incorrect reduction of the latter. The other

contributing factors which are of the same importance, are the application of the bandage with the forearm in supination and also the excessive flexion of the elbow. The blood vessels are compressed between the sharp lower edge of the upper fragment and the forearm (Figs. 8—9). In these fractures the radial pulse very often cannot be palpated before the reduction; after the reduction the pulse reappears. If the blood vessels are compressed between the fragments, swelling of the arm takes place quite rapidly. If now a circular bandage is applied, there is an additional constriction which leads to a rapid development of disturbances of the circulation; this, however, is not the primary cause of the latter. Ischaemic contractures have actually been observed without the use of any bandage, because in these cases, the fragments have been excessively displaced. The reason why these contractures occur only in children and not in adults, is to be explained by the fact that fractures from a fall on the over-stretched arm in adults, take place very rarely. In the latter, the same mechanism of the accident brings about a dislocation of the elbow.

The secondary paralysis of the radial nerve, which sometimes occurs in children, is caused by the application of the plaster cast with the forearm in supination, therefore giving rise to a varus position. The nerve rides astride on the sharp upper edge of the lower fragment and is here compressed. The compression disappears if the forearm is pronated (Figs. 8—9).

In children, the bandage is left on for four weeks. The finger-joints should be moved to their entire range from the first day. One can note in this connection that the muscles of the shoulder-joint are simultaneously activated. Two to four weeks after the removal of the plaster cast and the extension bandage, the elbow-joint is freely movable without the use of any particular after-treatment.

In adults with T or V-shaped fractures of the lower end of the humerus, the cast is left on for five to six weeks or even longer, dependent on the degree of the original displacement of the fragments. A few days later, most of the patients are able to supinate the forearm without any trouble. Extension and flexion of the upper joint are free in simple fractures and in younger individuals after four to six weeks. In older individuals it takes a longer time. Occasionally a permanent limitation of movements results.

Isolated Fractures of the Condyles of the Humerus

If there are no displacements present, a plaster cast is applied and kept on for four weeks (see page 78). If there is a pronounced displacement particularly with a rotation of the joint surface, it is occasionally possible to reduce the fragment by the introduction of a nail into it through the skin. If this is not feasible, the fracture must be exposed by an open operation and the fragment fixed by means of a wire or a nail.

Small fractures of the epicondyles where the fragments are dislocated into the joint, can be treated only by means of an open operation; the fragments can either be removed or fixed in their proper place with a few sutures.

The saucer-shaped fractures of the capitulum must be treated by an open operation. An incision is made on the lateral side and the fragment removed from the elbow-joint.

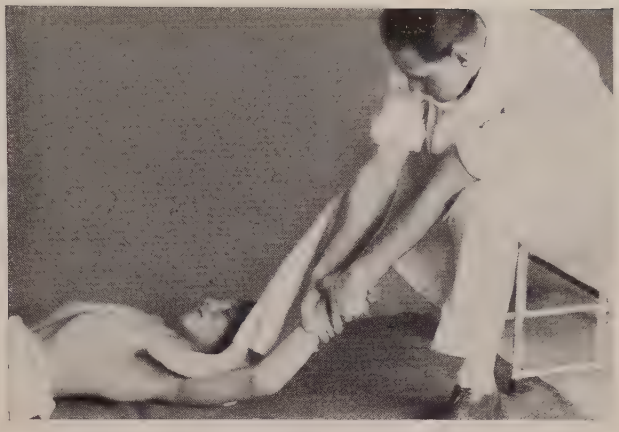


Fig. 102

The reduction of a separated epiphysis at the upper end of the humerus. The shaft, which was displaced medially and posteriorly, is brought into its place by pulling it against the heel applied on the antero-superior surface of the humerus.

Fig. 103

A poorly applied Middeldorpff's triangle for treatment of a fracture of the humerus. A few turns of the bandage are applied over the injured instead of the normal shoulder. The splint has slid down and the fracture has therefore assumed a valgus deformity. The arm is rotated inwards. The hand and fingers are very much swollen, blue and stiff.

Fractures of the Humerus in Children and Juveniles

Separation of the epiphysis is common in *the upper end of the humerus*; usually there is an adduction deformity with an angle facing inwards and backwards. The upper end of the lower fragment can frequently be palpated on the anterior surface of the shoulder under the skin.

Since the fragments are firmly hooked against each other, it is impossible to reduce the axial kinks and the rotation displacement by raising the arm laterally and rotating it outward. We shall show later how separations of the epiphyses at the lower end of the tibia and at the lower end of the femur are treated by placing the fragments over a wedge. In the fractures of the upper end of the humerus in young individuals, the patient is laid on the floor and the surgeon places his heel anteriorly and externally on the patient's shoulder.

The axial deformities can then be reduced by forcing the humerus against the heel, using the latter as a fulcrum (Fig. 102). The arm is then placed on an aeroplane splint and an extension pull applied. If the reduction has been correct, full use of the arm returns after four or five weeks.

Fractures of the shaft of the humerus are relatively rare in children and are treated in the same manner as in adults.

Supra-condylar fractures and also those through the condyle are very frequent in children. For the treatment see page 78.

Fractures of the Humerus complicated by Paralysis of the Radial Nerve

On account of its close anatomical relation to the humerus, paralysis of the radial nerve is frequent. In simple fractures, the nerve is usually either stretched or compressed between the fragments; it is seldom torn. Many surgeons consider paralysis of the radial nerve in fractures of the humerus as an indication for an open operation. According to our opinion, this complication is a contra-indication for operative interference. If the reduction of the fracture of the shaft or the supra-condylar region is properly performed and an adequate longitudinal pull exerted, the nerve is freed from pressure and its jammed position. The paralysis disappears in the course of a few hours or after two to four weeks. If, from the position of the fracture, there is a suspicion that the nerve is pinched, we employ the screw traction apparatus for the reduction, because we can exert a safe and at the same time a powerful pull in separating the fragments.

The exposure of the nerve in compound fractures is particularly dangerous if it has not already been found in the wound. If the fragments in a compound fracture are sutured, infection frequently takes place and the sutures introduced into the nerve ends also come out. In 54 cases of paralysis of the radial nerve, I saw 18 cases in which the function returned spontaneously.

If the paralysis does not recover after four to five weeks, the case must be operated upon. The nerve is exposed by a long incision. First, the normal parts of the nerve are exposed above and below the seat of the fracture and followed down to the scar or the callus where the hidden parts are found. The nerve, which is embedded in scar tissue or in the callus, is freed with the scalpel or with the chisel; usually it is quite thick. The nerve is then placed so that it is not in close approximation to the bone. Occasionally one observes that the ability to extend the fingers returns after a few hours.

If the nerve is completely torn, the stumps are removed and the normal appearing ends of the nerve are anastomosed. If the space between the nerve endings is too great, the bones must be shortened.

If the paralysis is still present a year following the operation, a tendon transplantation is performed. The flexor carpi radialis is transplanted into the tendons of the abductor longus and extensor brevis of the thumb and the flexor carpi ulnaris is transplanted to the extensors of the other four fingers and the extensor longus of the thumb.

Compound and Infected Fractures of the Humerus

Recent compound fractures are treated by excising the soiled tissues and by primary closure of the skin. See page 45. The nerve is sutured only when the wound is an incised one and not lacerated or contused. If there are large defects in the skin, it is sometimes necessary to shorten the bone in order to be able to approximate the skin edges again.

Infected fractures are treated in the same way as the simple ones. Fractures of the upper end of the humerus are treated by extension, using adhesive plaster, and those below the middle by a plaster cast with a window provided for the wound. In high fractures of the humerus, we can start with movements of the elbow-joint as soon as the temperature becomes normal. If it is necessary to operate on account of pus accumulation, the arm should not be removed from the aeroplane splint.

Errors of Treatment

If the arm is immobilized by the aid of Middeldorpff's triangle, it is brought into a most unfavorable position (Fig. 103). The fragments are rotated against each other, the forearm is in the maximum degree of supination, the blood vessels are pressed upon in the axilla and in the elbow, the hand hangs down and the fingers cannot be clenched to make a fist. In this way, the back of the hand and the fingers become very much swollen, the joints grow stiff, the muscles become atrophic and the fracture heals in a poor position. Outward rotation is not possible later, as a result.

In fractures near the elbow, if the same splint is used with the forearm in supination, a pronounced varus and flexion deformity of the lower fragment takes place. Blood vessels and nerves are compressed, ischaemic contracture of the muscles is apt to result and the movement of the elbow is greatly restricted.

FRACTURES OF THE FOREARM

Fractures of the Upper End of the Ulna

Fractures of the olecranon without displacements are treated by the application of a non-padded plaster splint which reaches from the upper third of the humerus to the base of the finger-joints. The splint is placed over the dorsal surface with the arm flexed at a right angle and with the forearm in a mid-position; the wrist-joint is brought into a slight dorsal flexion. The splint is fixed by surrounding it with a bandage and is left on for four weeks.

In fractures of the olecranon with diastasis, the central fragment is pulled upward and rotated by the triceps. The divergence of the fragments

is only possible when the extensor aponeurosis is torn. If the fragments are not approximated and forced to heal in a good position, the elbow-joint loses its ability to extend actively. The olecranon can easily be pressed against the ulna, if the elbow is extended. The extended position, however, unfavorably affects the blood circulation and after the bandage is taken off the fragments frequently separate again.

The most suitable thing to do in fractures of the olecranon is to unite the fragments and suture the extensor aponeurosis by an open operation. We can either employ local or regional anaesthesia of the brachial plexus. We wait about a week after the accident, or longer, if there is an injury to the skin, until we can operate through healthy tissues.

The fracture is exposed by a transverse incision. The effusion of blood is removed from the joint, and the torn tendons and periosteum removed from between the fragments. The olecranon is then approximated very exactly to the ulna by using a bone forceps. The olecranon can be fixed either by a nail or by a rustless wire first passed through holes drilled through both bones, and tied. The periosteum is sutured with silk and the skin closed. A plaster cast is applied for four weeks.

The fractures of the coronoid process of the ulna are treated by the application of a non-padded cast for four weeks.

Fractures of the Upper End of the Radius

If the head of the radius is fissured in its long axis, or is broken off without any displacement, it is treated by the application of a plaster cast which is left on for four weeks, and in the same manner as the fractures of the olecranon. If the head is splintered and the fragments are displaced, or when the head is broken and dislocated, it is very seldom possible to obtain a good position. The rotations of the forearm are either quite limited or disappear altogether. In these cases, it is therefore best to remove the head. The incision is made on the lateral side but should not reach too far anteriorly, because small branches of the radial nerve are apt to be injured. A plaster cast is given for two weeks.

Fractures through the Shafts of both Bones of the Forearm

The muscle action in this region is very complicated, because in addition to the muscles of the forearm, we also have muscles which extend and flex the elbow, the wrist-joint, and the finger-joints, and also rotate the wrist-joint in every direction. All muscles, with the exception of the pronator quadratus, tend to produce a shortening. The muscles which rotate the forearm, and the extensors and the abductors of the thumb, have the tendency to approximate the four fragments in the interosseous space. The fact that the muscles exert various actions

on both bones makes the orientation of the displacement very difficult. The flexors and the inward rotators are stronger than the extensors and the outward rotators, therefore the hand usually falls in pronation. Because the muscles on the radial side are stronger, there is a more or less pronounced dislocation of the radius to the longitudinal axis of the ulna in most of the cases. The lower end of the radius, which is usually longer than that of the ulna, slips behind the latter so that the styloid process of the ulna is made to stand out considerably. Both bones of the forearm are not in a straight direction, but show some concavity towards the interosseous space and towards the flexor surface.

On the upper end of the radius only the muscles rotating the forearm are inserted. On account of this, fractures which take place above the insertion of the pronator teres force the upper fragment into supination and those below the insertion of the same muscle, force the upper fragment into a mid-position; the lower fragment is always pronated.

In order to reduce these fractures we must first correct the axial and rotation deformities by placing the forearm in a proper position. The shortening is reduced by a longitudinal pull and the lateral displacement by pressure from the side.

The following items are needed for the reduction and immobilization of the fracture:

(1) A hook fixed to the wall, or a door handle (Fig. 104).
(2) A strong strap or a bandage folded several times, 10 cm. wide (Fig. 104).
(3) A board 25 × 10 × 2 cm. (Fig. 104).
(4) A board 100 to 150 × 10 × 2 cm. (Fig. 104).
(5) Mastisol and a gauze bandage.
(6) Four plaster of Paris bandages 5 m. × 15 cm.
(7) A calico bandage 10 m. × 12 cm.
(8) 2 little wooden rods 6 cm. long and 1·5 cm. thick, pointed at both ends.
(9) A wire splint (Cramer) 30 × 6 cm.
(10) A rustless pointed wire.
(11) A small board to spread the extension bands.
(12) A needle holder.
(13) Local or plexus anaesthesia, see page 16 (Fig. 15).

First, good lateral and antero-posterior X-Ray pictures are taken. The patient is then placed on the table and about 15 to 20 cc. of a 2% novocaine solution injected between the fragments of each bone. A pad 10 × 15 cm. is placed on the flexor surface of the arm just above the elbow. A strap is placed over the padding and fixed to the hook on the wall or to a door knob. About 20–30 cm. distance from the arm, a board 25 × 10 × 2 cm. is introduced between the strap in order to prevent the latter from pressing upon the muscles. A long board is placed between the wall and the foot of the table to prevent slipping

of the latter (Fig. 104). The first four fingers of the injured hand are now painted with Mastisol, the thumb covered with a calico bandage and the other three fingers also covered together. The assistant begins to pull slowly avoiding sudden change and exerting a great deal of power, by holding the thumb with one hand and the other fingers with the other hand (Fig. 104). The pull on the thumb should be stronger than that on the fingers. In this way the shortening at the seat of the fracture and the longitudinal displacement in the lower radio-ulnar articulation are reduced. The assistant has a good hold on

Fig. 104

The position of the patient in the reduction of fractures of the forearm. The counter-traction is exerted by a strap attached to the wall. A board is introduced between the strap to prevent pressure on the muscles, and to give room for the application of the bandage. An assistant exerts a pull on the fingers which have previously been painted with Mastisol. He supports his foot against a table made stationary by a board which is placed between the table and the wall.

the fingers which cannot slip because they are covered with gauze. The counter-extension applied above the elbow with the arm at a right angled position, by means of the strap, is to be preferred to the use of a second assistant, because the pull is entirely even. In fractures of the upper third, the hand is put in supination while in those of the middle and lower third, the hand is placed in mid-position. While the assistant continues to pull, and immediately after the shortening is reduced, strong pressure is applied with both thumbs and index fingers on the extensor and flexor surfaces of the forearm in the interosseous space. In this way

the four fragments are pressed apart and reduced. A gauze sponge 4 × 6 cm., folded eight times, is placed between the thumb and the index finger. A plaster splint 70–75 cm. long is fashioned from a plaster bandage, and two transverse strips, each 4 cm. wide, are excised from the end of the splint. The splint is placed on the extensor surface of the upper extremity beginning at the base of the finger-joints and reaching to the upper third of the arm. A small incision is made on each side of the cast at the elbow in order to prevent folds in the cast; the ends of the cut splint are folded over each other and covered by the small strips of the plaster splint previously made, in order to reinforce the cast at the elbow-joint (Fig. 105). The splint is fixed by a calico or gauze bandage. Another plaster splint, 30 cm. long by 8 cm. wide, is applied on the flexore surface of the forearm from the wrist to the elbow and again fixed with either a calico or a gauze bandage. On the dorsal splint a wooden rod is applied, somewhat peripheral to the middle, and over the flexor surface another wooden rod is placed somewhat central to the middle of the forearm; these rods are fastened with a bandage and pressed against the interosseous space with a strong but even force (Fig. 106). When pressing in the wooden rods, the palms of the hands are held in such manner that the one on the flexor surface is nearer to the elbow and the other on the extensor surface of the forearm nearer to the wrist-joint (Fig. 106). In this way the angular deformity with the open angle pointing to the dorsal surface, produced

Fig. 105

The dorsal plaster splint has been applied and a wooden rod placed to keep the bones apart in the interosseous space.

Fig. 106

The position of the operator's hands in pressing the wooden rods against the interosseous space and in producing a volar concavity of the forearm.

by the longitudinal pull, is corrected; the normal concavity of both bones of the forearm which points to the flexor side is therefore re-established. If the wooden rods are placed directly over the skin they are apt to produce pressure necrosis. When they are placed above the plaster splint they form a gently sloping curve against the skin which leads to no disturbances. As soon as the plaster becomes hard, the assistant releases the pull and the strap above the elbow is removed. The areas on the arm which are exposed are now covered by a plaster bandage. The assistant who pulls on the arm usually is fatigued after some time and is therefore replaced by another one.

Fig. 107

Fig. 108

Fig. 107. The completed plaster cast with a diagram of the X-Ray film and with the dates of injury and of removal of the plaster cast. The patient is opening and spreading his fingers.

Fig. 108. The arm is placed on the back.

The control examination by the X-Ray is now made and in most cases it shows a good reduction. If, however, this should not be the case, the cast must at once be removed and a new attempt to reduce the fragments made. In this manner we have always succeeded in obtaining a good position of the fragments without having resorted to an operation.

It is, however, not always possible to maintain a good position. If there is much swelling and displacement of the fragments, the arm is placed on an aeroplane splint. If in spite of this, there is still much swelling, the bandage must be opened between the thumb and the index finger, and if even this does not help, the whole cast must be split open on the radial side. In oblique and splintered fractures of the radius, especially if there existed beforehand a dislocation between the radius and ulna at the wrist-joint, the radius slips back and a shortening

with a displacement of the fragments towards the interosseous space takes place. This also occurs even if the fragments, once reduced, are fixed in the cast. These displacements can be avoided by introducing a rustless wire through the tip of the thumb and fastening it to a Cramer's splint which has previously been fixed to the dorsal side of the forearm (Fig. 113).

If the displacement and the splintering of the fragments of both bones are quite extensive, and if there are any open wounds present, a good position can be maintained by the use of wire extension. In addition to the items enumerated on page 85 we also need the following:

(1) 2 strong rustless wires, each 2 mm. thick.
(2) 4 screw-caps for fixation (Figs. 59, 112).
(3) 2 U-shaped tractors according to Beck (Fig. 59).
(4) 1 drill (Fig. 59).
(5) Anaesthesia of the brachial plexus (Fig. 15), see page 16.

Fig. 109
The arm is placed behind the head and the fingers closed to make a fist.

After the displacements in the lower radio-ulnar articulation have been reduced in the manner described on page 85, the fixation of the fracture is now carried out in the following manner: The procedure takes place by the use of brachial anaesthesia. One wire is introduced through the olecranon and a second one immediately above the wrist-joint; if the fracture is near the wrist-joint, a second wire is introduced through the second to the fifth metacarpal bones inclusive (Figs. 110–112). The incisions into the skin for the introduction of the wires are made by a tenotomy knife. The skin should be pulled on the olecranon posteriorly and in the wrist-joint anteriorly, in order to avoid folds in the skin. The U-shaped tractors are now attached at both ends of the forearm, the arm harnessed in the screw traction apparatus and an adequate pull exerted (Fig. 110). The arm is now fixed in a plaster cast by the use of two plaster splints, two wooden rods for the interosseous space and one or two circular bandages as described on page 86. The hand can be placed in light dorsi-flexion since no traction is exerted on the fingers (Fig. 112). The application of the plaster cast is particularly convenient above the-elbow joint, since one is not disturbed by the strap; the absence of the latter is also advantageous because the blood vessels are not compressed. As soon as the plaster becomes hard and after the X-Ray examination shows that the position is good, the U-shaped tractors are removed and the adjusting screw-caps are applied on each end of the protruding wires. The bits of wire

which stick out are cut off and filed. These two wires, which pass through the bones and which are fixed by the plaster cast, prevent the slipping back of the fragments. If there is any considerable swelling, the whole arm is placed on an aeroplane splint. With the forearm dressed in this way and lpaced on an aeroplane splint the fingers swell very seldom. If, however, this should happen, the cast must be split on the flexor surface near the radial side. In spite of the opening of the cast, the fragments do not become displaced again.

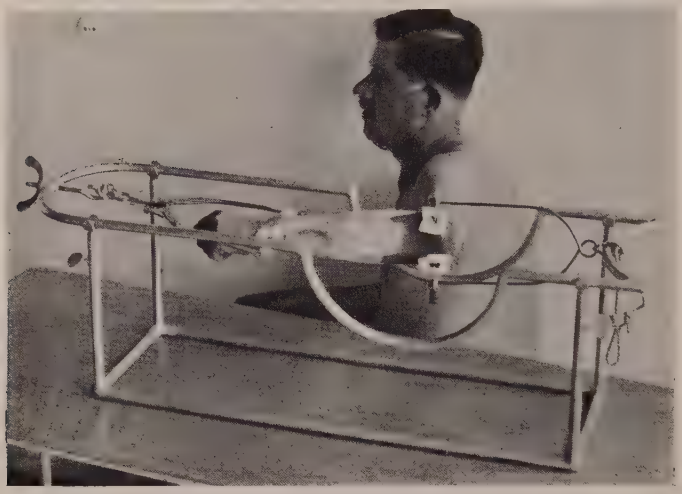


Fig. 110

Fractures of the forearm reduced in a screw traction apparatus by exerting a pull either with a nail or tongs applied above the wrist-joint. Brachial plexus anaesthesia. In place of the nail or the tongs the pull can be exerted also by the use of rustless wire.

In all fractures of the forearm where there is considerable displacement of the fragments, an X-Ray picture should be taken every two weeks.

The *after-treatment* starts at once. The patients must open their fingers to the whole extent; also close them, and spread them from the first day. The shoulder-joint must also be exercised by moving the arm so that the hand touches the occiput of the head and also the back (Figs. 107 – 109). Some patients can do these exercises actively from the

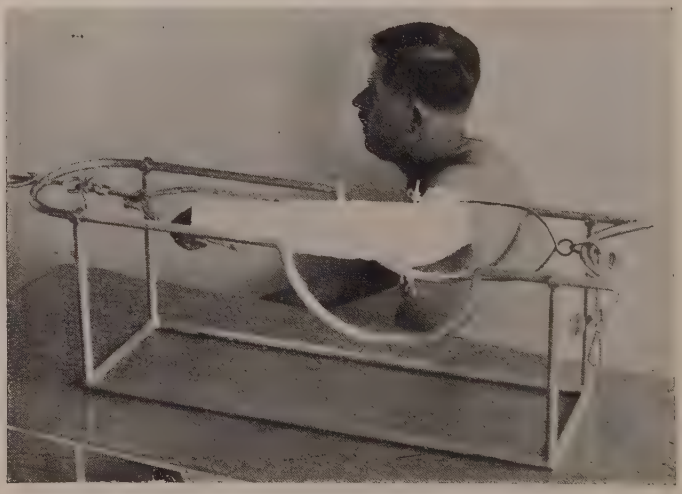


Fig. 111

The plaster cast has been applied.

first day. Others raise the arm with the other hand. Particular attention must be paid to the complete flexion in the finger-joints. Since the muscles controlling the action of the fingers also flex the hand and partially the elbow, and also extend the wrist-joint, and since the biceps and the triceps pass over the elbow-joint, the fixed elbow-joint will not become stiff if the fingers are constantly exercised. After the plaster cast is removed, the movements of the elbow-joint, which had been fixed, are free at once to one-half of their extent. Young patients are able to move the elbow-joint normally after one or two weeks, while in older persons it takes a longer time. Normal movements are soon re-established by the aid of baking, warm baths, diathermy, exercises on the pulleys and the use of Schede's splint.

The duration of the immobilization. Bony union is rarely obtained in transverse fractures of the middle third of the radius, before eight weeks; occasionally ten to twenty weeks of immobilization are needed. The conditions for callus formation are here as unfavorable as in the middle third of the tibia, see page 19. If the dressing is removed too soon, new displacements occur, especially bendings against the dorsal and ulnar sides, forming concavities towards the flexor and radial surfaces. If in addition to this, movements and massage are instituted, pseudarthrosis frequently ensues. Fractures near the wrist-joint and near the elbow-joint are occasionally firmly united after six weeks.

Fig. 112

A compound comminuted fracture of both bones of the forearm, reduced in a screw traction apparatus and the reduction maintained by the use of wire introduced through the olecranon and through the lower ends of the radius and ulna. The wires are held in position by nuts and the ends are cut away. A window is provided for the wound and protected by Cramer's splinting. The whole arm is placed on an abduction splint, in order to prevent circulatory disturbances. The fingers are not swollen and can be completely closed.

Fractures of the Shaft of the Ulna

If there are no displacements present, a dorsal plaster splint is applied from the base of the finger-joints to the elbow. The forearm is placed in mid-position and the wrist-joint in light dorsi-flexion. The splint is left on for four weeks. If displacements of the fragments are present, they must be reduced and fixed in the same way as the fractures of both bones of the forearm. The dressing is left on for four to six weeks.

Fractures of the Shaft of the Radius

In fractures of the radius in its upper third, the proximal fragment is always found in supination, and in those below the insertion of the pronatores, it is found in a mid-position. The lower fragment, together with the whole hand, is always in a pronounced pronation. In fractures of the lower third, the peripheral fragment is greatly approximated to the ulna and often deviated towards the flexor surface and slipped backwards in the peripheral radio-ulnar articulation. The deviation of the radius towards the ulna is in part caused by the pull of the pronator quadratus. The abductor pollicis longus and the extensor pollicis brevis which are wound around the radius, are responsible in a much greater degree, through their pressure, by forcing the peripheral fragment against the interosseous space and against the flexor surface while the forearm is pronated. In addition to the chief action of extending and abducting the thumb, these muscles are also supinators of the forearm. The action of these two muscles can therefore be excluded if the hand is brought into a complete supination. By employing full supination of the hand and by exerting a powerful pull on the thumb, this fracture can always be reduced without resorting to an open operation. If it is not reduced, both of the thumb muscles are left between the fragments and pseudarthrosis frequently occurs. All the fractures of the radius must be fixed and dressed in the same way as the fractures of both bones of the forearm, see page 86. If there is a complete lateral displacement and also shortening present, extension must be instituted by the use of a wire introduced through the thumb.

The Fractures of the Lower End of the Radius (Colles' Fracture)

In these cases, the peripheral fragment is usually displaced to the dorsal and to the radial sides and therefore rotated in the direction of supination; sometimes there is also shortening and pronounced splintering. The styloid process of the ulna is often broken off also.

The following items are needed for the reduction and the treatment of this fracture:

(1) A hook fixed in the wall, or a door handle (Fig. 104).
(2) A strap 10 cm. wide or a firm bandage.
(3) A board 100 to 150 × 10 × 2 cm.
(4) Mastisol and a gauze bandage.
(5) A sponge 4 × 6 cm.
(6) A plaster bandage 5 m. × 15 cm.
(7) A calico bandage 10 m. × 12 cm.
(8) A starch bandage 5 m. × 10 cm.
(9) Local anaesthesia, see page 16 (Fig. 15).

First, X-Ray pictures in the antero-posterior and in the lateral places are taken and then the patient is placed on the table. The fracture is rendered free from pain by the injection of 20 cc. of a 2%

novocaine solution. If there is considerable displacement present, it is sufficient to inject the solution through the dorsal side only. In fractures with little displacement, an injection should also be made through the flexor surface. If the styloid process of the ulna is also broken, a separate injection must be made. A pad 10×15 cm. in size is placed above the elbow-joint and the strap which is attached either to a hook on the wall or to a door handle, is placed over the padding. The first four fingers are covered with Mastisol and gauze. The little finger is left free. A powerful longitudinal pull is now applied simultaneously with a forceful bending of the hand to the volar and ulnar sides and with pronation of the hand. In this way, the displacement of the distal fragment to the dorsal and radial sides as well as the shortening and the supination, are reduced. The hand of the patient is now given to an assistant who holds the thumb with one hand and the other three fingers with the other hand. The assistant exerts a constant pull which must be stronger on the thumb. The remaining three fingers must lie exactly beside each other and not override. If there is a splintering and impaction of the lower fragment present, both hands are applied against the fragments with strong pressure. This is an easy matter if the solid shaft has been previously freed from its impaction into the spongiosa of the joint. A sponge 4×6 cm. in size, is introduced between the thumb and index finger and fastened with Mastisol. The arm is now placed with the elbow at a right angle, with the forearm in mid-position between pronation and supination and with the wrist-joint in mid-position between volar and dorsal flexion. A non-padded plaster splint 25–30 cm. long, is applied on the dorsal surface of the hand and the dorsal surface of the forearm and wrapped around with a calico or gauze bandage. The two turns of the bandage which run around the hand should not be pulled too tightly. The plaster splint is now very exactly moulded in at the wrist-joint. With one hand on the splint, pressure is applied towards the flexor surface moulding it tightly, and with the thumb of the other hand, the slightly convex part of the splint is smoothed out against the wrist-joint (Fig. 114). The moulding and the pressing of the splint at the site of the fracture and the pulling must not cease until the cast has had time to become

Fig. 113

A compound splintered fracture of the radius with a subluxation of the lower radio-ulnar articulation. The position is maintained after the reduction by extension with a rustless wire introduced through the tip of the thumb.

thoroughly hard. The strap is now removed and a control X-Ray picture taken. The position of the fracture is only then considered satisfactory if the lateral X-Ray picture shows that the joint surface of the radius stands either perpendicular, or bent slightly to the volar side in relation to the shaft; and when the antero-posterior picture shows an angle of 30° between the shafts and the joint surface. If there is still a displacement present, the bandage is removed and another attempt made to reduce the fracture more exactly. If the fingers are very much swollen and cyanotic, the calico bandage is removed and applied loosely. A new displacement cannot take place because the plaster splint surrounds the wrist-joint in two-thirds of its circumference; this leaves sufficient space for the blood circulation. On the following day, the splint is wrapped with a starch bandage on which the X-Ray picture of the fracture is sketched. The date of the accident, of the reduction and also the date of the proposed removal of the splint is recorded. As soon as the pain is gone, the patients frequently forget when the accident occurred and when they had been directed to come back; they occasionally lose their out-patient cards. The starch bandage should not be applied too tightly, because in contrast with the plaster, it shrinks after it becomes dry. The starch bandage should not reach beyond the calico bandage into the bare skin, because its sharp edges might cut into the skin after the bandage becomes dry. In the ordinary fractures, this dressing is left on for three weeks, while in those with pronounced splintering which are more frequently seen in old people with brittle bones, for four to five weeks. If there is extensive splintering present, an X-Ray examination must be made eight days after the reduction.

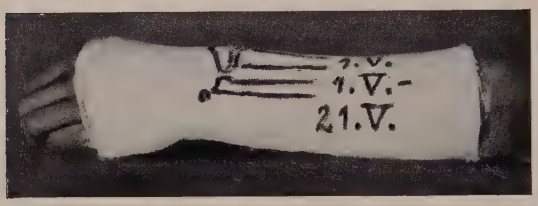


Fig. 114

A plaster dressing applied for a usual Colles' fracture. The wrist-joint is extended in a slight ulnar abduction. The plaster is well-moulded over the wrist-joint. The X-Ray film is reproduced on the cast. The dates of injury, of the reduction and when the cast is to be removed are written on the bandage.

In the rare cases in which the central fragment is approximated to the ulna and where the shorter fragment has slipped backwards in the lower articulation of the radius, we must apply in addition a volar splint. Two wooden rods are pressed in on the dorsal and ventral surfaces against the interosseous space and a pull exerted by using a rustless wire introduced through the tip of the thumb. For technique see page 92.

In the *rare fractures* where there is a displacement of the fragment to the *volar side*, the reduction is made by a powerful dorsal flexion and a plaster splint applied with the wrist-joint in dorsi-flexion.

The *after-treatment* starts at once. The patient is allowed to move his fingers as soon as the bandage becomes sufficiently hardened. After half an hour, the hand is inspected for any swelling or discoloration. Then one directs the patient to open his fingers completely, also to close them and spread them. If this is not yet possible actively, he must do it himself passively with the other hand. Great attention must be given in this connection in seeing that the terminal joints of the fingers be also flexed and that the thumb be not adducted to interfere with full flexion of the fingers. The fingers must be flexed 90° in the basal joints, 110–120° in the middle joints and 65–80° in the terminal joints; the terminal joints and the basal joints must completely touch each other. Then one lets the patient extend his thumb completely and adduct it in again until it touches the basal joint of the little finger. The forearm must also be pronated and supinated. This movement is the most difficult to execute and every patient tries to avoid it by pronating and supinating in the shoulder-joint. We must therefore direct the patient to support his elbow on the thigh and only then to rotate the forearm. At the beginning it is only possible to rotate the forearm actively to a slight degree.

The patient must therefore fully rotate the injured forearm himself with the aid of his normal hand. Then follow the movements of extension and flexion of the elbow-joint, the patient touching the back of his head and his back with the hand of the injured forearm. In order not to produce disturbances in the movements of the shoulder-joint, one sees to it that the latter movements are performed with the arm in the frontal direction and not in the sagittal plane. In old people with extensive splintering of the fracture, there is always a large haematoma and extravasation of blood on the inner side of the elbow-joint. The latter becomes firm and painful if the arm is carried in a sling continuously. On the other hand if systematic exercises are performed, the haematoma remains soft, is quickly absorbed and does not produce much further trouble. In older people, if the shoulder is not moved and exercised, pain sets in in about ten to twelve days and there are also disturbances in the movements which disappears only after a few months or never do. If the shoulder is moved, such disturbances are never seen. If the swelling has disappeared, the patient is directed to begin his exercises on pulleys on the third or fourth day after the injury. For this purpose a pulley is screwed in the wall or the door post at the level of the shoulder, in the patient's dwelling. At least three times a day, the patient pulls a weight ten to twenty times over this pulley. The latter is rapidly increased so that in a few days, he is able to pull as much with the injured arm as with the other one. It is only necessary to carry the arm in a sling for the first few days and often the sling can be dispensed with altogether. After two or three days, the hand can usually be employed for the easier manipulations. Old ladies find it particularly agreeable because they can at once again tie their apron

strings and do their hair themselves. I recently saw a seamstress aged 56 who resumed her work three days after the reduction of a Colles' fracture with extensive displacement of the fragment. If the hand is immobilized in volar flexion, the finer movements of the fingers, such as required for instance in sewing, are utterly impossible. In this particular case, the woman was not insured against sickness or accident and the ability to perform her duties was necessary in order to earn her daily bread. I saw younger people chopping wood with a plaster dressing a week after the injury. Writing is also possible after a few days. The plaster splint should never be removed before firm union of the fracture takes place. After the splint is removed, the wrist-joint can at once be moved to half of its extent. The other limitations of movements practically all disappear in the course of a week, because the stiffness which is present in the wrist-joint from the immobilization, is compensated by the constantly employed active movements and the work of the free muscles to their full extent. If the splint in the more difficult cases is removed before three weeks, one finds that the seat of the fracture in most of these, is still tender to pressure; the dorsum of the hand and the fingers also become swollen and there is no power in clenching the fist.

In this form of treatment, both fragments are completely immobilized; the same applies to both joints of the wrist. All the other joints remain completely free. All the forty muscles of the forearm and the hand can be actively moved; also the pronator quadratus which is actually injured. The capsule and the ligaments of the wrist-joint do not shrink, because the tendons constantly glide over the latter. If the active movements in the manner described are used, the circulation of the whole arm remains normal. Oedema of the dorsum of the hand does not take place and there are no disturbances in the nutrition of the skin (shining skin), the muscles or the bones. Young people are able to resume their work five to six weeks after the injury; older ones after six to ten weeks.

Fractures of the Forearm in the Young

These fractures in children and in juveniles are treated in the same manner as in adults. If there are no lateral displacements present, the dressing can be removed after three to four weeks. Otherwise it is left on for five to six weeks. In the greenstick fractures above the wrist-joint, the axial displacements must be carefully reduced.

The separation of the epiphysis in the lower end of the radius often shows very pronounced displacements with a wedge of bone broken on the extensor surface of the shaft. The reduction of this displacement is brought about by a strong longitudinal pull and by a very powerful maximum volar flexion of the wrist-joint. The plaster splint is left on for three weeks with the wrist in mid-position. After

the latter is removed the movements are at once free. If this fracture is properly reduced no disturbances of growth take place.

Compound and Infected Fractures of the Forearm

Compound fractures of the forearm which are seen a few hours after the injury, are treated by débridement and by primary closure of the skin and then in the same manner as in simple fractures.

If an infection has already set in, the fracture must be immobilized with particular care and the immobilization must not be interrupted. These are reduced and dressed in the same manner as are the simple fractures. Windows are formed in the plaster over the wounds. The wound is left open and protected by placing a wire netting, taken from a Cramer's splint, and fixing it to the plaster. The arm is placed on an aeroplane splint and kept in this position as long as the fever persists.

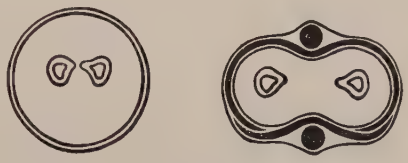


Fig. 115

Left: A cross-section through a fractured forearm after the application of a tight circular bandage. The cross-section of the forearm becomes circular and both bones are approximated to each other.

Right: The application of a volar and a dorsal wooden rod over the plaster, presses the interosseous space apart.

Mal-Union of Fractures of the Forearm

Serious disturbances arise from fractures which have healed with axial deformities, shortening, narrowing of the interosseous space, a dislocation in the peripheral radio-ulnar articulation or with a bridge callus.

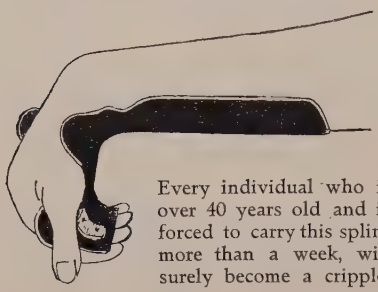
These cases should be operated on. Anaesthesia of the brachial plexus is used. The bones are exposed subperiosteally and both ends are chiselled through in step form and connected by means of rustless wire. One makes an attempt to reduce the axial deformities and to re-establish the normal width of the interosseous space. In order to correct the sub-luxation in the radio-ulnar articulation, the ulna must be correspondingly shortened. A plaster cast is now applied in the same manner as for the fresh cases. A posterior plaster splint reaching from the base of the fingers to the middle of the arm, a splint for the flexor surface with the usual pair of wooden rods and also a circular plaster bandage are used. The cast is left on for eight weeks or longer if necessary. For technique see page 85.

Errors of Treatment

If there is a pronounced displacement, it is impossible to maintain a correct position after reduction, by the use of a padded cast. By using tightly applied circular bandages the fragments are pressed together in the interosseous space causing an obstacle to rotation of the forearm

and producing a bridge callus (Fig. 115). Too short immobilization and massage and passive movements which are instituted too early, cause the fragments to become displaced again and occasionally a pseudarthrosis also occurs.

The dressing of fractures of the lower end of the radius (Colles' fracture) in pronounced volar flexion and ulnar abduction in people over 40 years of age, leads to serious disturbances of movement and frequently to permanent stiffness of the fingers and of the wrist-joint (Fig. 116).



Every individual who is over 40 years old and is forced to carry this splint more than a week, will surely become a cripple.

Fig. 116

Continuous carrying of the arm in a sling in older people leads to stiffness of the elbow and shoulder-joints.

FRACTURES OF THE SCAPHOID OR NAVICULAR

Massage and passive movements constitute a wrong form of treatment for these fractures; they heal with cavity formation and pseudarthrosis and later give rise to permanent disturbances, see page 27. If, on the other hand, a non-padded plaster splint is applied on the dorsal surface from the base of the fingers to the elbow-joint with the wrist in a light dorsi-flexion and ulnar abduction, these fractures always heal by bony union (Fig. 117). We do not advise placing the wrist in radial abduction because in this position the closing power of the fist is diminished. We have now had more than sixty fresh fractures of the scaphoid and all of them were treated in the manner described and always healed by bony union.

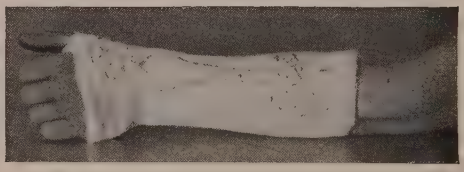


Fig. 117

Plaster dressing applied to a fractured scaphoid. The wrist-joint is in a slight dorsi-flexion and ulnar abduction.

Fractures of the scaphoid process which do not involve the joint always heal by bony union, irrespective of the kind of treatment employed. The pain ceases at once after a dorsal splint is applied. It is left on for two weeks.

If the fractures of the scaphoid are not immobilized, the cleft between the fragments becomes progressively wider, and in about four or five weeks, a cavity is formed between the fragments. If such a fracture with a delayed union is treated by immobilization with a dorsal plaster splint, which is maintained for four to six months, the cavity disappears and bony union takes place (Figs. 32–34). These cases have a painful and a slightly swollen hand which they are not able to use. After the dorsal splint is applied, the pains disappear and the patient

can work again. An X-Ray picture is made every month. After the dorsal splint is taken off, the wrist-joint can be freely moved, either immediately or after one or two weeks.

The removal of the scaphoid in recent or in old fractures with cavity formation is absolutely contra-indicated, because it is a mutilating and disabling procedure. If the scaphoid is removed on account of a fully developed pseudarthrosis with arthritis deformans, the complaints still remain in most of the cases. The hand tends to assume the position of radial abduction and is therefore very much weakened. Powerful clenching of the fist is only possible with the wrist in ulnar abduction.

FRACTURES OF THE SEMILUNAR OR THE LUNATE BONE

Fissured fractures are treated in the same way as fractures of the scaphoid; by the use of a dorsal plaster splint which is left on for five to six weeks.

The *compression fractures* of the semilunar bone are treated by extension with a rustless wire introduced through the tip of the middle finger. While a powerful pull is exerted by means of the wire, an attempt is made to reduce the narrowed semilunar by applying pressure. A continuous pull lasting eight to ten weeks is applied to the middle finger by the aid of a finger wire splint and a dorsal plaster splint. For technique see page 101.

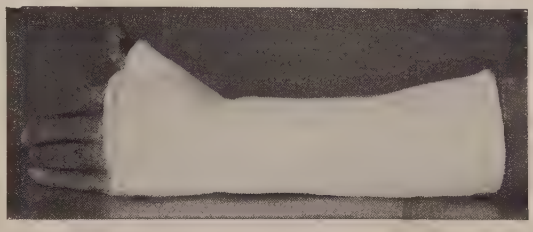


Fig. 118

Plaster dressing for a Bennet's fracture-dislocation of the first metacarpal bone. The hand is in slight dorsiflexion. The plaster is well moulded over the site of the fracture dislocation to produce a slight indentation.

FRACTURES OF THE OTHER CARPAL BONES

These fractures seldom occur and are treated by immobilization with a dorsal plaster splint in the same manner as the fracture of the scaphoid.

FRACTURES OF THE METACARPAL BONES

Fractures of the First Metacarpal Bone

The most common fracture of the first metacarpal bone is the one which goes by the name of "Bennet". The ulnar wedge of the base is broken off and the thumb is dislocated towards the radial and dorsal sides. By pulling on the thumb and pressing against the fracture with the finger, one can feel how the dislocated bone slips in. The broken

off fragment also assumes its normal position again. As soon as the pressure is released, the bone slips out of its place again. The fragments can be maintained in a good position by the use of a dorsal plaster splint which also covers the basal phalanx of the thumb. For this purpose it is also important to mould in a flat indentation over the site of the fracture, exerting at the same time a concomitant pull on the thumb (Fig. 118). This form of treatment suffices only in the case where the small fragment is broken off outside of the joint. If, however, the fragment is wider and involves a smaller or a larger part of the joint surface, a new subluxation can only be prevented if, in addition to pressing the fragment into its place, a continuous longitudinal pull is also exerted by means of a steel wire introduced through the tip of the thumb (Figs. 120–125). The dressing is left on for three weeks.

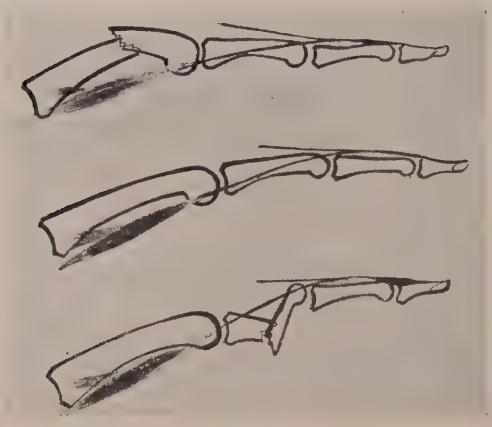


Fig. 119

The pull of the lumbricales and the interossei is so directed that the fractures of the metacarpal bones are displaced so as to produce an open angle facing the palmar side while those of the first phalanges produce an open angle deformity facing the dorsal side.

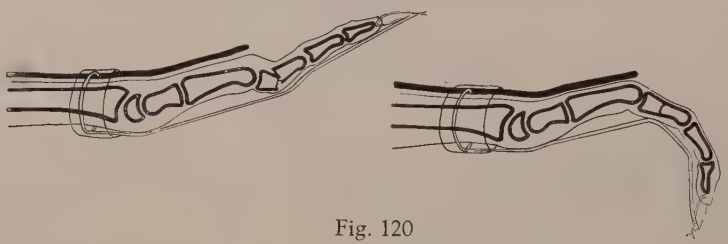


Fig. 120

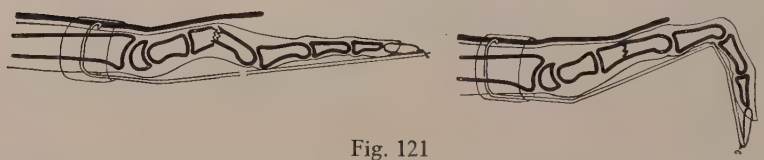


Fig. 121

Fig. 120. The fractures of the basal phalanges are treated by fastening the finger wire splints to the wrist-joint with a plaster splint and by fixing a rustless steel wire introduced through the tip of the finger to the finger splint. The finger is bent in such manner that the basal, middle and terminal joints are flexed for an angle of 45 degrees respectively.

Fig. 121. In fractures of the metacarpal bones, the basal joint is left extended, while the middle and the distal joints are bent for an angle of 45 degrees. The plaster splint is well moulded over the seat of the fracture, so as to produce an indentation.

Transverse fractures of the base are characterized mostly by an axial displacement with an open angle facing the ulnar side. First, the seat of the fracture must be rendered painless by the use of local anaesthesia. The fracture is reduced by a sharp bending to the radial side. A dorsal plaster splint which takes in the whole thumb and only leaves the thumb nail free, is applied. The splint is removed after three weeks.

Fractures of the shaft of the first metacarpal bone are treated by continuous traction after the exact reduction has been made (Fig. 122).

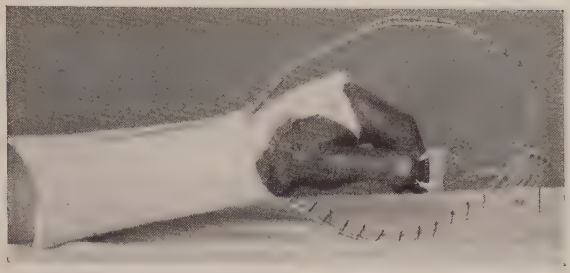


Fig. 122

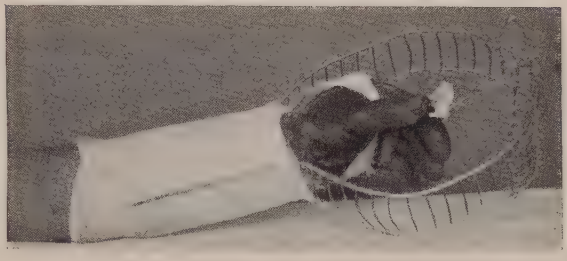


Fig. 123

Fig. 124

Fig. 122. Compound fracture of the first metacarpal bone. The pull is exerted by means of a rustless wire introduced through the tip of the thumb. A Cramer's splint is fastened over the hand in order to protect the exposed wound from the covers.

Fig. 123. The pull is exerted on a Cramer's splint attached to the original one.

Fig. 124. Fracture of the basal phalanx of the thumb. Placed on a finger splint with a pull by wire introduced through the tip of the thumb.

Fig. 125. Compound fracture of the basal phalanx of the index finger, placed on a finger splint with a pull exerted by a wire introduced through the tip of the finger. A basket made from Cramer's splinting for the protection of the exposed wound.

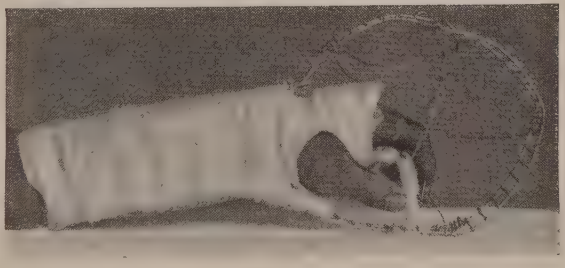


Fig. 125

Fractures of the Second to the Fifth Metacarpal Bones

These are either torsion, transverse or splintered fractures. The most common deformity which the fragments produce is an open angle

facing the volar side; such displacement is caused by the pull of the lumbricales and the interossei muscles (Figs. 119–120). These fractures are treated in the same manner as those of the fingers, with the only exception that the middle and the end joints of the corresponding finger are flexed, while the basal joint remains extended. For technique see page 100 (Figs. 119–120). The dorsal plaster splint should be well moulded to produce a flat surface against the site of the fracture, so as to prevent the recurrence of the protruding convex deformity to the dorsal side.

FRACTURES OF THE FINGERS

In the fractures of the basal phalanges, the common deformity produced by the fragments, is an open angle facing the dorsal side. This displacement occurs on account of the pull of the lumbricales and interossei muscles (Fig. 119).

The following items are needed for the treatment of these fractures:
(1) 2 plaster bandages 5 m. × 15 cm.
(2) Finger splints made of wire.
(3) Rustless steel wire 0·5 mm. thick.
(4) A needle holder.
(5) Small pieces of wood to keep extension wires apart.
(6) Local anaesthesia, see page 16 (Fig. 15).

First, about 10 cc. of a 2% novocaine solution are injected into the seat of the fracture and also into the tip of the finger. A dorsal plaster splint is applied with the wrist-joint in slight dorsi-flexion and a wire finger splint is fixed to another plaster splint applied on the volar side of the wrist-joint. The finger splint is made from strong iron wire 60 cm. long and 2 mm. thick; the wire is so bent in the middle that it becomes U-shaped, while its ends are bent at a right angle and rolled up to form rings (Fig. 62). The wire splint is padded with cotton or with sheet wadding. The rustless wire is now introduced through the tip of the fractured finger and twisted after the little piece of wood has been placed in between, and fixed to the end of the finger splint. The extended finger is now bent, flexing it in all its three joints till the mid-position. In this way the angulation of the fragments is reduced since the peripheral fragment is brought into the same direction into which the central one points. Besides this, a pull is also being exerted, because the radius of the curve produced by bending the finger splint, is smaller than the radius of the curve made by the overlying fingers. One must be careful that the pull exerted is not too great, because pressure sores may arise on the flexor surfaces of the fingers.

If, in place of wire extension through the tip of the finger, adhesive plaster is used, we see as a rule that in a few days it slips off and a new displacement occurs. In fractures of the third and fourth fingers, the latter must be sufficiently bent, because otherwise the other fingers

are hampered in their ability to flex. In fractures of the second and the fifth fingers, one must see that they do not deviate too much laterally. An X-Ray picture must be taken after the reduction and also after each week.

This dressing may at first sight appear very complicated. It is, however, compensated by establishing a proper reduction and good immobilization of the fragments and also rendering the patient free from pain. In addition to the above, the other fingers can at once be moved to their full extent and therefore do not become stiff.

Because the extensor and flexor tendons of the fingers have common muscles the fractured finger can again be freely moved within a short time after the dressing is removed. The plaster dressing is left on for three to four weeks.

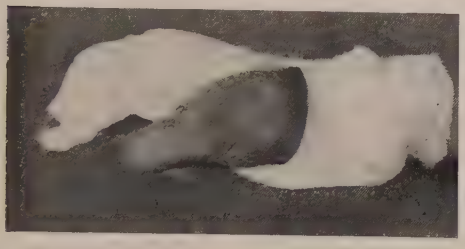


Fig. 126

Fig. 127

Fig. 126. A dressing applied for a tear of the extensor tendon. The finger is placed on a finger splint with the distal joint of the finger hyperextended.

Fig. 127. A celluloid finger-stall used for tear of the extensor tendon.

If more than one finger are fractured, they are treated in the same way.

Fractures of the middle and terminal phalanges are treated with the same form of dressing.

Fractures of the dorsal side of the base of the distal phalanx with a tear of the extensor tendon running over the distal joint, must be treated by dressing the finger with the terminal joint over-extended. One can use a finger splint which can be fastened by means of a starched bandage, or still better, a celluloid finger-stall which was recommended by Kulenkampf (Fig. 127). First, the fingers are covered with a slight coating of grease and then one finger of a cotton glove is drawn over the broken finger. The cotton finger is brushed with a solution, containing 1 part of celluloid in 10 parts of acetone, five to six times in the course of 2 hours. The finger must be kept in a dorsal flexion throughout the whole of this process. The finger-stall becomes hard after 2–3 hours. It is very light in weight and can be easily removed when the patient washes. It is worn six to eight weeks.

The suture of the torn extensor tendon is not advisable in most of the cases, because it gives an unsightly scar and because occasionally the suture material is thrown out from under the skin.

The fractures of the thumb without axial displacements are treated by extension with wire introduced through the tip and without a finger splint.

Errors of Treatment

The axial displacement cannot be straightened out by the use of tongue depressors or other straight wooden splints. The shortening cannot be reduced by the use of short curved splints.

If a bandage roll, placed in the hollow of the hand, is used for the immobilization of the fractured finger, it is impossible to exert a pull; with this form of treatment the normal fingers are also apt to become stiff.

Wire finger splints which are fastened on the wrist only by the use of a gauze bandage, and not fixed with a dorsal plaster splint, soon slip backwards and therefore exert no pull at all. A pull can be exerted only if there are two fixed points between which it acts; in this case one point is the plaster splint on the wrist-joint, and the other point, the wire in the finger tip.

Compound and Infected Fractures of the Fingers

Compound fractures are treated first by excising the lacerated tissues and closing the skin and then dressing them in the same manner as closed fractures. The wound is left uncovered by gauze.

Infected fractures of the fingers are treated in the same way, only the wounds are not sutured. The wounds are treated by exposure to air and protected by a wire netting made from Cramer's splint. (Figs. 122–125.)

FRACTURES OF THE FEMUR

Fractures of the Neck

As in every other fracture, also in that of the neck of the femur, the healing of the bone can be obtained if we are able to fulfil the fundamental rules for the treatment of bone fractures.

In the first place, we must correct the axial displacements. The deformity in the frontal plane which gives a varus position, with the open angle facing medially, is reduced by a powerful abduction of the leg. The displacement with the open angle facing posteriorly is reduced by an inward rotation of the leg. The lateral displacement, which is caused by the contraction of the muscles, is reduced by an adequately strong longitudinal traction.

First, a clinical examination is made and then an X-Ray picture is taken to corroborate the clinical findings. The treatment depends upon the general condition of the patient. In old people who usually suffer with respiratory and circulatory disturbances, we aim to prevent pneumonia, cardiac weakness and bed sores. We can best avoid these complications if we treat these patients with weight extension with the aid of

a rustless nail. (For technique see page 110.) The use of the pin in old people is less troublesome than the traction exerted by means of adhesive plaster. If we apply the proper abduction, the inward rotation, and adequate longitudinal traction, the fracture is spontaneously reduced in a few hours. We can easily recognize this without the aid of the X-Ray since we can palpate the descent of the trochanter major.

Very interesting is the influence of the reduction and the position on the general condition of the patient. After the reduction, the patients are free from pain when they are moving as well as when they are resting. Prior to the reduction, every coughing spell elicits heavy pain in the area of the fracture and on that account is anxiously avoided. After reduction, coughing causes little disturbance and the danger of pneumonia is greatly diminished. The patient is able to raise himself and move upwards and downwards if he needs the bed pan (Fig. 144). The care of the patient, the cleaning and sponging is not troublesome and no bed sores occur. The knee-joint can be moved a few days after the injury. Movements of the hip-joints should be avoided as much as possible. If the patient actively extends and flexes the knee, he employs not only the muscles of the thigh but also those of the abdomen and of the whole body. Concomitant with the work of the muscles, the heart and the lungs are also active. The contractions of the abdominal muscles have a definite stimulating effect on the activity of the bowels. We have seen quite often that people, who have suffered for years from constipation, have a daily normal bowel movement in spite of the recumbent position, provided they diligently perform the prescribed exercises. In this way the patients are continually occupied; their mental attitude is not morbid, since they are also free from pain.

In order to assure a bony union, the weight extension must be left on for six months. If the general condition of the patient, however, is improving, we can apply a walking cast one or two weeks after the accident. (For technique see page 124.) In young people and in those older ones who are not apt to suffer any serious complications, we apply a plaster cast with the thigh in abduction as advised by Whitman. This we consider the best method of treatment. In contrast to the typical Whitman position, we place the knee in an extended position and do not make an excessive inward rotation. For the reduction of these fractures we also use local anaesthesia. A 10–12 cm. needle is introduced immediately below the Poupart's ligament lateral to the femoral artery. The pulsation of the femoral artery must be palpated and then the needle advanced until bone is felt. If no bloody fluid appears from the needle, it is removed and another attempt is made to inject the joint from behind. 10–20 cc. of novocaine solution are then injected directly behind the greater trochanter. The fracture is then reduced and the plaster cast applied. (For technique see page 124.)

In fractures with a coxa valga position and in those with a firm impaction or in patients under 30 years old, the immobilization is suf-

ficient for three to four months. In these fractures bony union takes place sooner, since the bony fragments are in good opposition and not easily displaced. The blood vessels in the synovial membrane on the posterior side of the neck are not torn and therefore favorably affect the repair.

An impacted fracture should only be left unreduced if there is a coxa valga position without outward rotation. If, however, the impacted fracture is complicated by axial displacements, outward rotation or coxa vara, it must be dislodged and properly reduced.

Errors of Treatment

(1) If the reduction is omitted, no bony union in a proper position is possible.

(2) Bad position of the patient. If the mattress is not firm enough, or the boards under the hard horsehair mattress omitted, no freedom from pain is possible and the nursing is made difficult.

(3) The continuous weight extension position with the hip and knee extended and without the proper support for the foot. In this way, the free movements of the patient are restricted and the care of the patient is made difficult. The knee-joint becomes loosened.

(4) The use of light weights. A weight less than 8 kg. cannot reduce the existing shortening, or if the shortening is already reduced, such weight is insufficient to maintain the fragment in proper position.

(5) The application of a Volkmann splint. This splint fixes only the normal knee and ankle joint, but not the injured hip. In this way one deprives the patient of every chance of movement, while without this splint he can after some time, independently flex the hip and the knee and slide his foot on the support.

(6) Too short immobilization of the fragments. The application of any form of fixation for six to eight weeks is altogether useless if one desires to obtain bony union. On account of the anatomical peculiarities, the fracture cannot heal firmly in such a short time. If exposed to weight-bearing, the fragments will separate again.

Pseudarthrosis of the Neck of the Femur

If the general condition of the patient is not very bad, the best treatment of a pseudarthrosis consists in a subtrochanteric osteotomy, which was described by von Baeyer, Lorenz and Schanz. For this operation we require three rustless nails each 20 cm. long, two adjusting screws, a Steinmann nail and a U-shaped tractor, a hammer, a scalpel and a chisel. The operation is performed under lumbar anaesthesia. The angle between the head and the shaft of the femur is first measured on the X-Ray picture. A rustless nail, 20 cm. long, is driven into the greater trochanter. A second nail is driven into the shaft of the femur

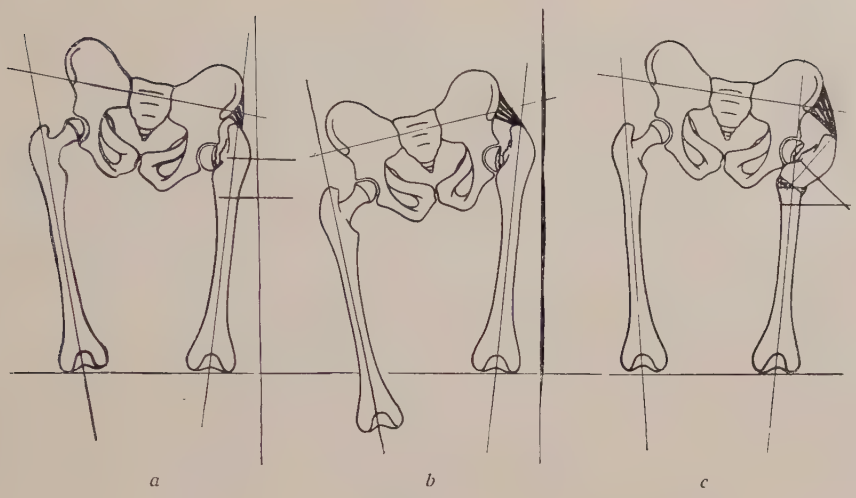


Fig. 128

a) Diagrammatic representation of a pseudarthrosis of the neck of the femur with the patient standing on both extremities. The extremity is shortened and displaced upwards. The pelvis is oblique, and the gluteus medius and minimus are very much shortened. Two nails parallel to each other are introduced into the femur. b) If the patient is standing on the broken extremity, the normal part of the pelvis sinks down until the trochanter minor touches the pelvis (Trendelenburg's sign). c) After a transverse osteotomy made exactly through the lesser trochanter, the pelvis, when the patient is standing, is equally supported on both extremities and does not therefore fall down any more during weight bearing. In addition to the above, the gluteal muscles are again tense and are therefore able to raise actively the opposite half of the pelvis.

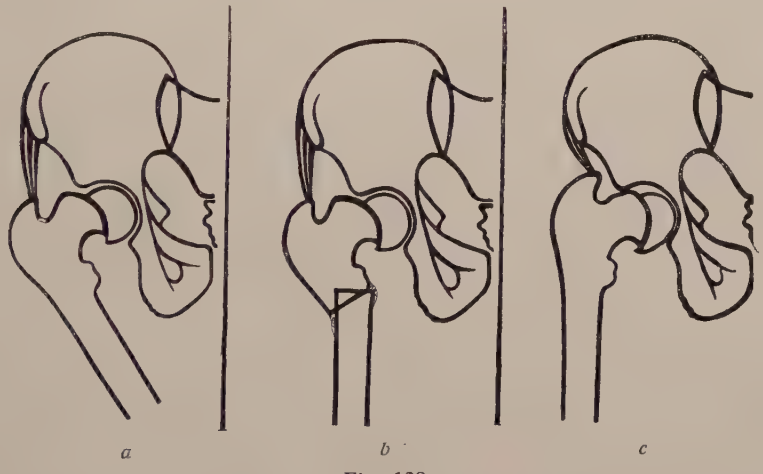


Fig. 129

a) Extreme adduction contracture after separation of the epiphysis of the head of the femur (coxa vara traumatica). b) After a subtrochanteric osteotomy, made exactly below the lesser trochanter, the angle between the shaft and the neck again becomes normal and the length of the gluteal muscles also becomes normal. c) The adduction contracture can be corrected by a powerful pull on the extremity laterally, but in doing this, the head of the femur is forced out beyond the lower edge of the acetabulum, and the cartilaginous covering is injured. The gluteal muscles are very much shortened. The result of this operation is frequently a bony ankylosis of the hip.

6–8 cm. below the first one and parallel to it. A straight incision 2 cm. long is made between both nails. This incision corresponds approximately to the level of the trochanter minor or directly below it. The femur is here divided transversely by means of a chisel. If the adductor muscles are very much contracted a subcutaneous tenotomy is performed. The peripheral part of the extremity is then abducted to an angle of 25–35°. This angle can be definitely determined with the help of both nails. The angle formed by the two nails introduced is equal to the angle formed by both fragments. The desired position of the nails is maintained by the use of a gauze bandage. To prevent slipping, the nails are provided with rings and adjusting screws (Figs. 56 and 128). If the osteotomy is performed without the nails, we are not able to determine definitely whether the abduction takes place in the site of the osteotomy, in the pseudarthrosis or in the hip-joint. The position obtained after the operation can be maintained in a plaster cast or by means of weight extension. In this case we introduce a rustless nail through the tibia and put the patient on a Braun's frame and treat the condition in the same manner as a recent fracture of the femur. See page 110. Eight to ten kilograms are used depending upon the muscular strength of the patient. After three weeks, the nail is removed and the weight extension resumed by means of the zinc-gelatine dressing. (For technique see page 120.) The patient is now allowed to move all of his joints. The plaster cast or the weight extension are left on for ten weeks. After this, the patients are at once allowed to walk. If they are treated by weight extension they are now able in most of the cases, to walk in about eight days without a cane, because the knee and the ankle joints are freely movable. If a plaster cast is used, it takes a few weeks before the patient is able to walk independently, on account of the stiffness of the joints and the atrophy of the muscles.

Separation of the Epiphysis of the Head of the Femur

In acute cases the reduction is possible by the use of local analgesia or general anaesthesia. By abduction and inward or outward rotation with a corresponding longitudinal pull, it is possible to bring the head again into its proper position. It can be treated in plaster cast, or better, by weight extension for eight to ten weeks after which weight-bearing is possible.

The old cases which have healed in a bad position are treated by a subtrochanteric osteotomy in the same manner as for pseudarthrosis of the neck of the femur. We aim to re-establish the normal angle between the head and the shaft. At the same time, the neck in its new position presses on the head which has slipped under the lower edge of the acetabulum and brings it into its normal position (Fig. 129).

After the operation has been performed, we prefer to immobilize in weight extension instead of in a plaster cast. The weight extension releases the pressure on the injured head by relieving the reflex spasm of the muscles. It also permits of the movement of the hip soon after the operation, thereby preventing a stiffness of the hip, which often takes place in these operated cases, if a plaster cast is used. After eight to nine weeks, the healing of the osteotomy is complete and the extremity is again able to withstand weight-bearing.

If instead of an osteotomy, the old separation of the epiphysis is treated by abduction and internal rotation, the head slips out still more from the acetabulum. On account of the powerful abduction, the softened head is frequently crushed. Such treatment often brings about a bony ankylosis of the hip-joint (Fig. 129).

Fractures of the Shaft of the Femur

In fractures of the upper end of the femur, the proximal fragment is abducted, outwardly rotated and flexed. Between both fragments in the frontal plane, there is an angle open to the inside, and in the sagittal plane, an angle open posteriorly; these angular deformities cause a varus position and a convex deformity facing anteriorly. The whole lower extremity, including the distal fragment, must be placed in extreme abduction. The flexion deformity and the outward rotation of the proximal fragment disappear spontaneously after the shortening has been reduced, and the distal fragment rotated inwardly. In the case of a fracture of the lower end of the femur, the distal fragment recedes backwards and forms with its proximal fragment an angle open anteriorly or in other words, a convex deformity pointing posteriorly. It is impossible to reduce this deformity by the manipulation of the smaller distal fragment alone. The gastrocnemius muscle attached to this fragment, forms one unit with the leg and the foot. The distal fragment, the knee-joint and the muscles which form one inseparable system, must be placed in the axis of the proximal fragment (Figs. 78, 79). The reduction of the axial displacements and the rotations of the fragments, is brought about by the proper position of the lower extremity. Since the displacements are in part due to the spasm and tension of the muscles, a 2% solution of novocaine is injected between the fragments in order to produce a relaxation.

If one wishes to immobilize the fracture by means of a plaster of Paris cast or by means of some splint, the shortening can be reduced by powerful pull with the hands or with the screw traction. If weight extension alone is used, the shortening usually disappears in a few hours. The lateral displacements are as a rule also reduced spontaneously, after the shortening disappears, since the fragments are surrounded by the muscles as if by an elastic tube. If, on account of the irregularity of the fragments and too much over-riding, they are hooked to each other,

we must pull with more force or use more weight in order to produce a more pronounced lengthening of the limb so that the fragments can pass one over the other. The interposition of soft parts is only present if there is a longitudinal displacement. After the shortening is reduced, the soft parts recede into their normal position. The most important consideration now is to maintain a corrected position uninterruptedly until bony union of the fragments is solid. This can be obtained by the use of a plaster cast, splints and weight extension. We usually employ weight extension. For this purpose we need the following items:

(1) One bed with a firm support (boards between the horsehair and the spring mattress) (Figs. 35, 36).
(2) A modified Balkan frame with two carriers for pulleys, four screws and a scissors-shaped wooden appliance to hold the splint (Fig. 52).
(3) A correctly wrapped Braun's splint.
(4) A rustless Steinmann nail with a U-shaped attachment (Fig. 56).
(5) A hammer.
(6) Adhesive tape 60 cm. long × 5 cm. wide with a wooden spreader 4 × 6 cm. (Fig. 94).
(7) A piece of thick hemp string 1 m. long and another piece 1½ m. long.
(8) Eleven 1-kilogram weights.
(9) One wooden box 25 × 30 × 40 cm.
(10) One step or two wooden blocks.
(11) Mastisol.
(12) Balsam of Peru.
(13) A gauze bandage.
(14) Tincture of iodine.
(15) Local anaesthesia outfit, see page 16 (Fig. 15).

After a patient with a fracture of the femur is admitted, he is first thoroughly examined. The shortening is measured and the extremity especially examined for possible injuries of nerves and blood vessels. The fracture is then rendered painless by the injection of 20 cc. of a 2% novocaine solution between the fragments. An X-Ray picture is made, the limb placed on a Braun's splint and the patient placed in bed. 5 cc. of 2% novocaine solution is injected into the skin and periosteum on both sides of the tibial tuberosity. The nail which has been previously sterilized and which is held by means of a sterile sponge, is driven through the tuberosity. The skin which is punctured by the nail, is painted with Mastisol. Small sponges which have been split and covered with a few drops of Balsam of Peru, are placed over the wounds. The U-shaped tractor is now attached to the nail. The foot and the adhesive plaster are painted with Mastisol after the plaster with the wooden spreader has been applied to the foot, and then fastened to the apparatus above by the aid of a gauze bandage. Ten to fifteen kilogram weights, depending upon the muscular strength of the patient, are suspended from the U-shaped tractor which is attached to the nail; one kilogram weight is attached for the foot traction. On the normal side, the

patient is given the box for the support of the normal foot. If ten kilogram weights are used, the foot of the bed is elevated 30 cm., while if 12 kilograms are used it is elevated 50 cm. In this way the weight of the body forms the counter-traction. The application of counter-traction against the perineum is not advisable, since the pressure is unpleasant to the patient. The suspension frame is connected with Braun's splint by means of the scissors-shaped wooden attachment and in such a manner that the knee fold fits exactly over the angle of the splint. At the same time the patient supports his normal extended extremity against the wooden box. The scissors-shaped wooden attachment prevents the displacement of Braun's splint, not only longitudinally, but also from side to side. In this manner, the pull exerted by the weights is directed in the desired axis and does not exert a varus or valgus effect. The box, which is used for the support of the normal extremity, places the position of the body always in the same relation to the suspension frame and the Braun splint, which all form one unit. The pulley is placed in such manner that it gives the string the direction of the axis of the femur. The pulley for the foot is placed above, corresponding to the middle of the leg, in order to bring the foot in a right angle with the leg. This position of the foot does not only prevent a drop-foot, but also an outward or an inward rotation. It also protects the heel and the tendo Achillis from pressure and bed sores, since the heel does not lie on the splint with the whole of its weight. These considerations are of importance since it may take many months for the pressure sores over the tendo Achillis to heal and because the sores frequently break open. The weight applied to the string (one kilogram) which runs over a pulley, enables the patient to move the toes and the ankle-joint at any time. This, therefore, prevents the stiffening of joints and atrophy of muscles.

The degree of flexion in the hip and in the knee can be left the same in all these fractures.

The degree of abduction depends upon the seat of the fracture. In high fractures, the proximal fragment is strongly abducted, exerted and flexed. In such cases we must bring the suspension frame together with Braun's splint in extreme abduction. The suspension frame crosses the bed obliquely and is fastened outside at the head and at the foot of the bed (Figs. 140–143). The flexion and the angular deformity facing posteriorly, always disappear spontaneously after the shortening has been corrected. The outward rotation of the proximal fragment also disappears after we turn the distal part of the extremity to the inner side until the patella faces anteriorly. The lesser trochanter, which is often broken off and deviated from its axis, also comes in its normal position. In purely rotation fractures in the region of the trochanter, where the greater trochanter is rotated outwards and slips upwards, without a formation of a coxa vara, the traction must be applied in the axis of the bed because otherwise a coxa valga develops. The stubborn

tendency of the fragment to rotate outwards, we meet by fastening the outside of the nail by means of a sling to the suspension apparatus (Fig. 130).

If the fracture is in the region between the upper and middle thirds of the femur, the suspension apparatus must be placed on the inside of the legs of the bedstead, since the abduction necessary is not as extensive

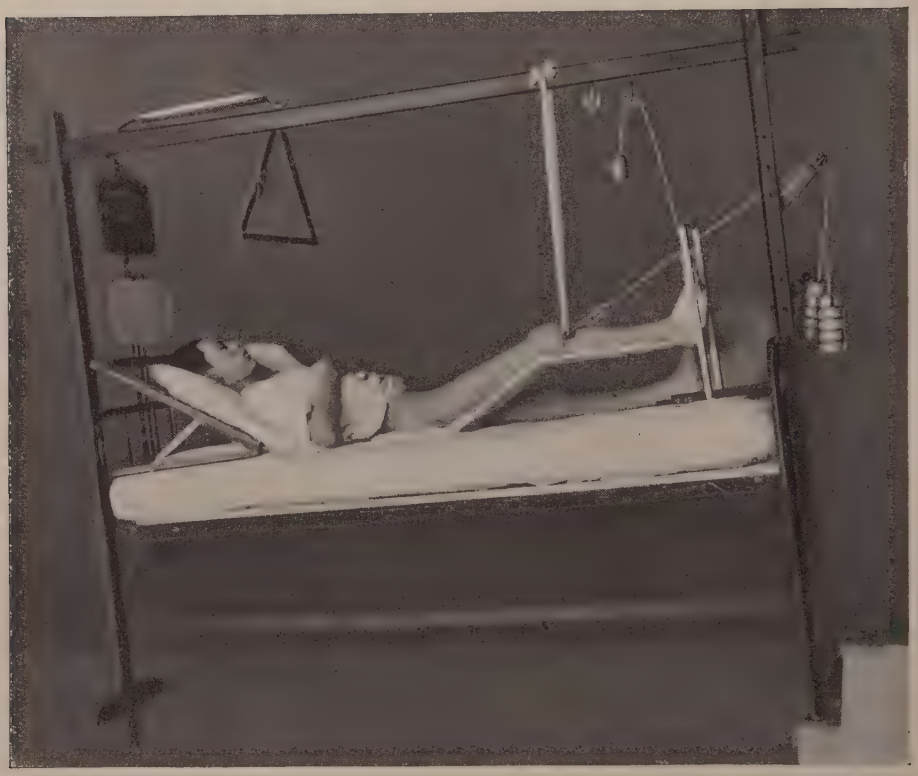


Fig. 130

A fracture of the shaft of the femur in the course of treatment. The extremity is on Braun's splint. The foot of the bed is raised 30 cm. 10 kilograms are applied to the nail introduced through the tuberosity of the tibia, and 1 kilogram for the foot. Inward rotation of the extremity is maintained by a bandage which is tied to the outer end of the nail introduced through the tibia and fastened above on the overhead frame. The normal foot is supported by the box. Boards under the horsehair mattress.

as in fractures higher up. If there is evidence that there is a slight varus or valgus deformity, it can be corrected by moving the suspension apparatus in the first place in the direction of abduction and in the last place in the direction of adduction. The advantage of the suspension apparatus, which is not fixed immovably to the bed is very great. Without much work or trouble it can be moved in any desired direction.

If the fracture is lower than the middle of the femur, the suspension apparatus is placed in the axis of the bed.

In fractures of the lower third of the femur, we are frequently unable to correct a valgus position, that is an angle open to the outside, by changing the direction of the suspension frame. This deformity takes place, because the lower fragment is actually abducted on account of the weight traction which pulls the pelvis in oblique direction (Fig. 131).

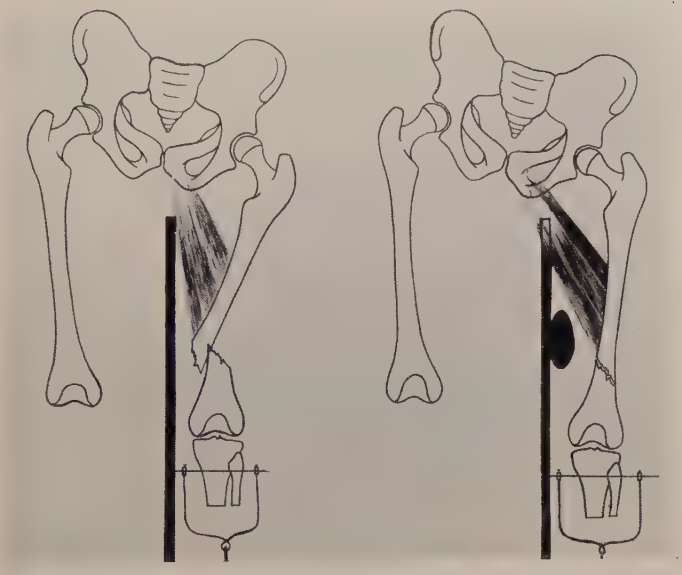


Fig. 131

Left: Supracondylar fracture of the femur with a valgus deformity on account of an oblique position of the pelvis and the pull of the adductors.

Right: The reduction of the valgus deformity by introducing a padding on the inside of the upper fragment.

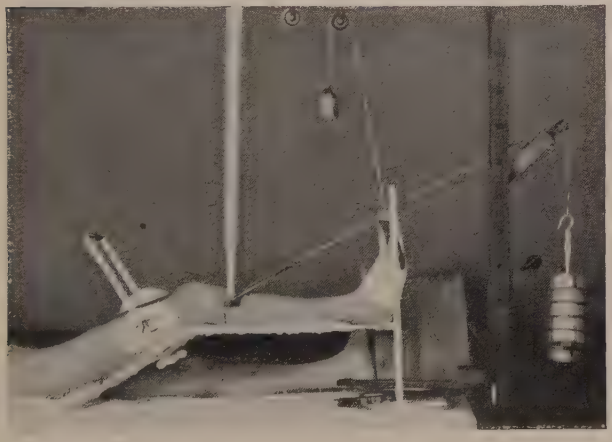


Fig. 132

Supracondylar fracture of the femur. The valgus deformity and the gap between the fragments corrected by using a U-shaped iron frame provided with holes at the base through which the iron screw pressure-pads are adjusted.

In this case the position is corrected by super-imposing a U-shaped attachment over a Braun's splint and introducing sufficient padding on the medial side. My assistant Dr. Schnek has bored holes through the legs of the U-shaped iron, so that we are now able to exert lateral pressure by means of a screw and small pressure-pads (Fig. 132).

This form of lateral pressure enables us to correct the deformity when combined with a longitudinal pull of the distal fragment and eliminates the use of a lateral pull (Fig. 131). We should always attempt to avoid a lateral pull, since it constricts the extremity in its circumference and may even give rise to pressure sores.

The deformity, the result of a displacement of the distal fragment backwards from the combined pull of the gastrocnemius and the short head of the biceps, shows an open angle in the sagittal plane anteriorly and can be reduced in the following manner:

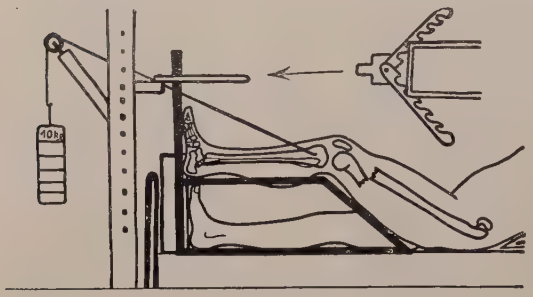


Fig. 133

A supracondylar fracture of the femur with a typical displacement of the lower fragment posteriorly. The knee cleft lies directly over the angle of Braun's splint.

The scissors-like attachment is released from Braun's splint and the latter moved up towards the pelvis so that the knee cleft lies peripheral to the knee angle of the splint. The pressure of this angular projection of the splint against the distal fragment together with the longitudinal pull, brings about the reduction. If Braun's splint is moved too far upwards, the deformity is even apt to be over-corrected, and an angle open posteriorly, i.e. with a convexity facing anteriorly is apt to take place (Figs. 133–136).

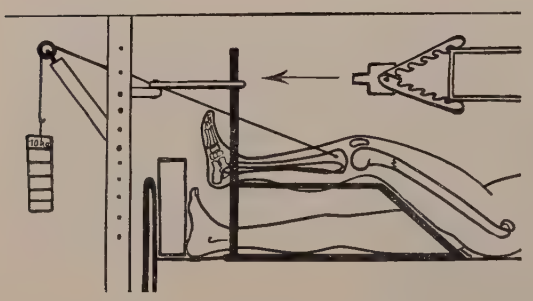


Fig. 134

Braun's splint is displaced upwards and held in place by the scissors shaped wooden appliance. The lower fragment is now over the angle of the splint and is therefore pushed anteriorly.

After having placed the extremity in its proper position with all the necessary adjustments as well as the application of sufficient weights, measurement or examination of the fracture by means of an X-Ray, usually discloses that the shortening and the other displacements are reduced.

The reduction of the fracture before the leg is placed on a Braun's splint, or before weights are applied, is not necessary. The result of our examination is worth while only if comparison is made with the uninjured extremity with its articulations in the same degree of flexion, abduction and rotation in which the injured one is found. The extremity is measured by placing the one end of the tape, which is held between the index and thumb, on the anterior-superior iliac spine, and the other end on the inferior edge of the patella. In order to avoid mistakes, we

should not read our results with the tape measure in place, but only after it has been taken off. Figs. 137, 138 show the different results obtained in measuring the same extremity in various degrees of abduction and flexion.

In fresh fractures, for weight extension we use the nail which is driven through the tuberosity of the tibia. We do not place the nail through the femur, because many serious complications have been reported from the introduction of the nail or ice-tongs through the lower end of the femur. The use of the nail and the tongs through the femur in fractures near the joint, has resulted in infections of the knee-joint, in haematoma, osteomyelitis, knee stiffness and has sometimes rendered amputations necessary. Fatalities following these complications have also been reported. If the nail is introduced through the tuberosity of the tibia, there is no danger of penetrating the suprapatellar bursa of the knee-joint or of entering the haematoma. This part of the tibia is particularly firm. The tendons of the extensors of the leg are here inserted. The cutting through of the nail in this place is therefore impossible. The tongs should never be applied in this situation because there is not sufficient hard bone for the tongs to get a deep hold, and because they can easily slip from the surfaces of the tibia which approach each other anteriorly. The tongs should only be applied in such places where the bone becomes wider distal to their insertion; the sites most suitable for the application of the tongs from the anatomical point of view, are the condyles of the femur and the calcaneus. The pull exerted

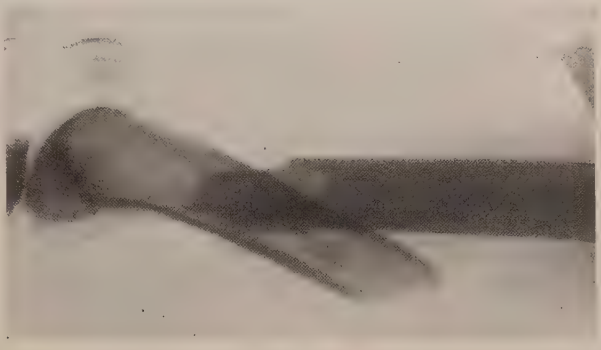


Fig. 135

Roentgenogram of a supracondylar fracture of the femur corresponding to the position represented in Fig. 133.

Fig. 136

Roentgenogram of the same case as in Fig. 135, the position of the splint being changed to that seen in Fig. 134. The knee cleft is peripheral to the angle of the splint.

directly on the bones by means of a nail is always preferred to the pull by the use of adhesive plaster, zinc-gelatine dressing or any other method. The use of a nail is devoid of any dangers and gives the possibility of exerting a powerful pull. The introduction of the nail takes only a few minutes, while for the application of any other form of traction, a quarter of an hour, or even more, is necessary. During this time, the extremity is moved in various directions and, if the assistant happens to be clumsy, new injuries of muscles, nerves and blood vessels may take place. Moreover, the extension bandage constricts the skin, a matter which is of importance in the first days of the treatment.

After the weight extension is applied, the pains disappear in a few hours and only exceptionally remain

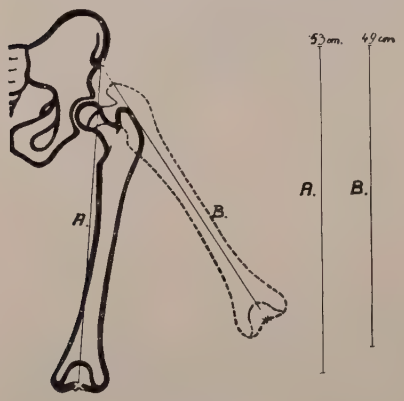


Fig. 137

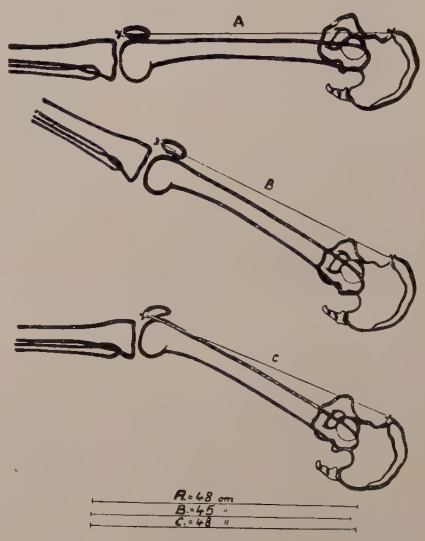


Fig. 138

Fig. 137. When the lower extremity is abducted, the greater trochanter is nearest to the pelvis. On account of this, the distance between the anterior-superior spine and the patella is 4 cm. shorter with the extremity abducted 40 degrees than if the extremity is adducted.

Fig. 138. The distance between the anterior-superior spine and the patella is 3 cm. shorter if the hip is flexed and the knee extended than if the hip and the knee are both extended or if the hip and the knee are both flexed at an equal angle.

for a few days. If the patient supports his healthy extremity against a box and holds himself by the trapeze, he can move up and down and sideways. He does not have to lie continuously in the same place and therefore does not get any bed sores. By flexing the knee of the sound leg, he can also raise his pelvis. He needs no help if he wishes to use the bed pan. He can also be attended to and cleaned without much trouble. The free movements are possible because the string with the weight attachment runs only over one pulley and also because the weights are hanging freely. In this way the excursion of the weights cannot be restricted by any other part of the extension unit. The toes and the foot can always be actively

Fig. 139

The application of a zinc-gelatine extension dressing with traction exerted on the nail still in place. The buttocks are on the pelvic support. Two longitudinal strips for the extension of the thigh have been applied.

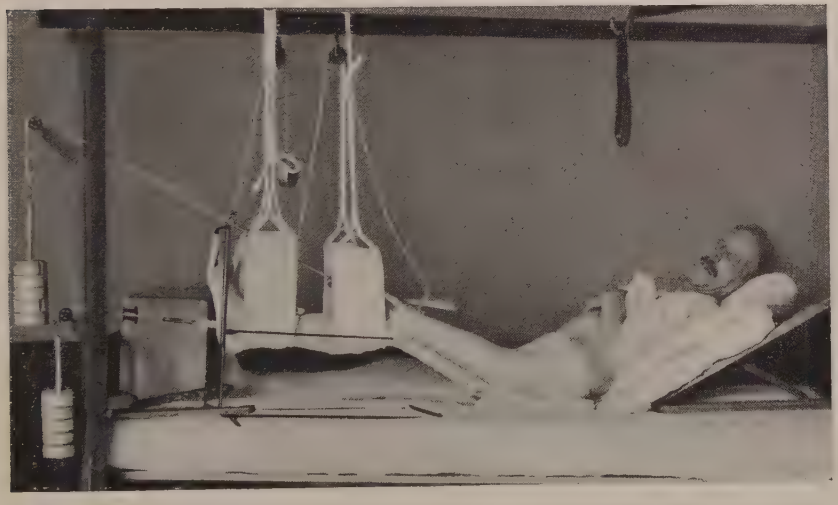


Fig. 140

Zinc-gelatine extension dressing applied to the thigh, to the leg, and to the foot. 5 kg. weights are attached for the thigh and for the leg respectively and 1 kg. for the foot. The leg is suspended by two straps.

moved and if the patient sits up, the hip-joint can also be moved against the immobilized femur.

Fig. 141

Traction movements of the knee-joint. All the weights are temporarily attached to the thigh. The apparatus for the knee exercises has been given to the patient in order that he may be able to flex his knee more acutely.

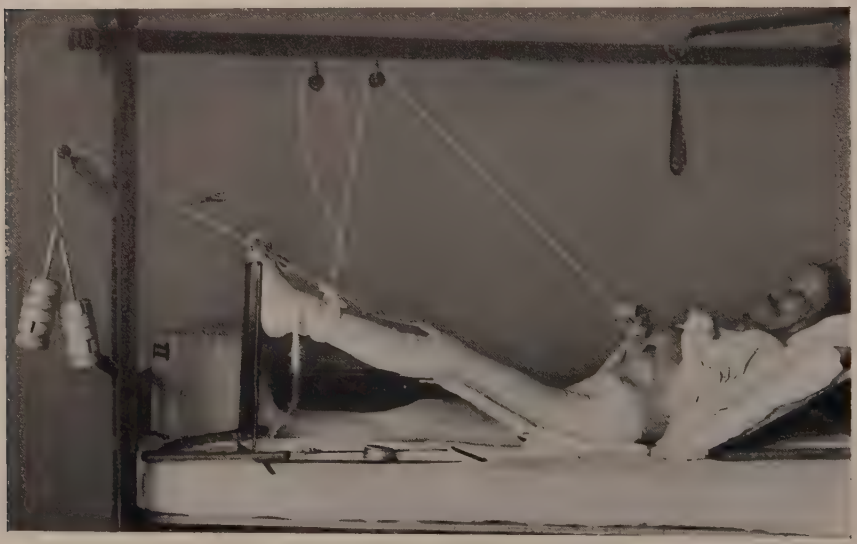


Fig. 142

Stretching exercises of the knee joint.

If there are signs of an inflammation or infection about the nail, it should be removed. If rustless nails are used, infection takes place

Fig. 143

By sitting up, the patient is able to flex his hip-joint.

Fig. 144

By forcing the normal leg against the box, the patient is able to raise his pelvis without help when he needs the bed-pan.

very seldom. The nail should not be left in the tibia longer than three weeks, since there is danger of loosening of the knee-joint. After three weeks, a zinc-gelatine extension dressing is used and the nail left until weights are applied to the new extension dressing (Figs. 139–144).

The Zinc-Gelatine Extension Dressing

The following items are needed for this dressing:

(1) 300–400 grams of zinc-gelatine (for preparation see page 29), also an adequate receptacle.
(2) A wide brush.
(3) 2 gauze bandages 15 cm. × 10 m. and one 10 cm. × 10 m.
(4) 2 pairs of strong calico strips 90 × 15 cm. for the thigh and the leg, and 2 strong strips of calico 40 × 15 cm. for the foot. They are laid together fourfold.
(5) 2 large and 1 small U-shaped tractors (Fig. 67).
(6) 3 strong strings.
(7) 11 kilogram weights.
(8) 1 sacral support.
(9) 2 suspension bandages.

The buttocks are placed on the sacral support with the weight extension continuously maintained on the nail. The zinc-gelatine is kept fluid in a water-bath, and is brushed over the pelvis and thigh, which are at once evenly wrapped by the gauze bandage. The longitudinal strips are put on each side of the thigh, brushed over with the zinc-gelatine paste, again bandaged over with gauze bandage and again covered by the paste. The longitudinal strips emerge on each side, a hand-breadth above the knee-joint. The longitudinal strips for the leg are applied with the knee flexed in the manner described for the thigh. These strips should also emerge a hand-breadth on each side above the ankle-joint. The ankle and the foot are then covered by the zinc-gelatine paste and longitudinal strips applied on the dorsal and on the plantar surfaces of the foot. The foot must be in a position of dorsi-flexion. The zinc-gelatine extension dressing is left on until the next day or until it is dry; the weights can even be applied 2 hours after the application. The drying can be accelerated by sponging this dressing with a 6% solution of formalin in alcohol.

Weight Extension by Means of Adhesive Plaster

Adhesive tape can be used in place of the zinc-gelatine dressing. For the application of the adhesive tape extension we need the following items:

(1) 2 sets of adhesive strips 5 to 6 cm. wide and 100 to 110 cm. long for the thigh and the leg, and also 2 adhesive strips 50 cm. long for the foot.

(2) 3 small boards with holes bored in the middle. One 10 × 6 cm. for the thigh, the second one 8 × 6 cm. for the leg and a third one 4 × 6 cm. for the foot.
(3) Mastisol.
(4) 2 gauze bandages 10 cm. × 10 m.
(5) 3 strong strings for the pulley.

The plaster must reach over the whole longitudinal extent of the thigh, even if the fracture is in the lower end, since the shortening is caused by all the muscles which must be brought into relaxation by the pull. The adhesive strips are separated into three parts a hand-breadth above the knee and the same distance above the ankle. This is necessary in order to prevent the cutting of the strips into the skin (Fig. 146). The ends of the adhesive strips are rolled on wooden tongue depressors to prevent the adhesive from kinking and sticking to the skin (Fig. 94). After the plaster is applied to the skin, it is painted, together with the skin, with Mastisol and surrounded with a gauze bandage. The adhesive plaster is applied to the leg and the foot in a similar manner. The weights can be attached 1 or 2 hours later.

The nail is removed from the tuberosity of the tibia only after weights are applied to the new extension dressing; 5 kg. are applied for the thigh and the same weight for the leg. If the nail is removed before these weights are applied, a new displacement of the fragments is liable to take place. The sponges are removed from the skin and the sharp end of the nail is thoroughly cleaned with benzine and painted with tincture of iodine. The nail is now removed by the use of a pair of flat pincers applied to the dull end. The removal of the nail is difficult only in the first days, when it is still firm in its place; after three weeks it is quite loose. If an infection in the holes of the skin takes place, they should never be treated by constant sponging and lavage. These infections heal very rapidly if we just cover small areas with a few drops of Balsam of Peru and bandage them. On the other hand, if the bandaging is changed too often, the wounds become irritated and fistulae result which do not heal for a long time.

After the zinc-gelatine extension dressing is applied, the gauze bandage is removed from the horizontal part of Braun's splint and the leg is suspended by means of two suspending bands. The ankle is well padded and a sling applied over the padding. The sling is attached to a string which passes over a pulley fastened to the longitudinal bar of the overhead frame; the end of the string is given into the hands of the patient. And now, if the weight attached to the leg is temporarily disconnected and added to the weight on the thigh, and the weight suspending the foot is also temporarily taken off, the patient is able to passively extend and flex the knee-joint by manipulating the string. After a few days, the knee-joint can also be moved actively (Figs. 141, 142). In fractures of the upper half of the femur, these exercises can begin immediately after the application of the extension dressing. In fractures

below the middle, it is better to wait five weeks after the injury. The zinc-gelatine extension dressing usually becomes loosened in the thigh after two or three weeks, and in the leg, after four or five weeks; it must therefore be frequently renewed. If there is pressure over any part of the dressing, it must be cut open in this particular place. The weight extension does not suffer in spite of this cut.

In this way the functional treatment by movements can be best carried out. See page 121. The joints can be actively moved with the

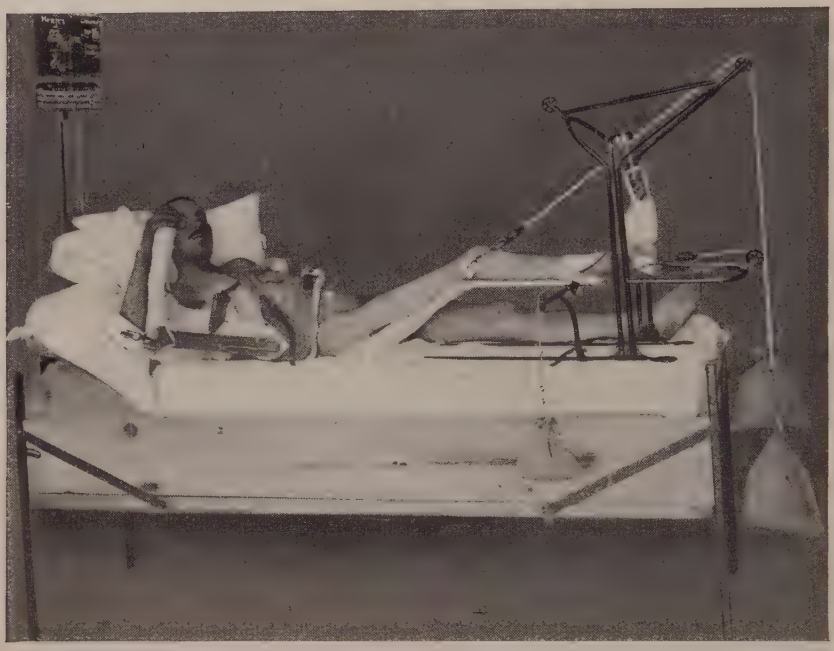


Fig. 145

A compound fracture of the femur and of the leg and also a closed fracture of the humerus in the course of treatment. Schmerz clamps applied to the femur and to the heel. The forefoot is suspended from a pulley above. A lateral pull is applied to the leg. The arm is placed on an abduction splint.

fragments remaining immobilized, on account of the extension and of the position of the extremity in the splint. The patient is completely free from pain. Stiffening of the joints and atrophy of muscles cannot take place. On account of the active movements, blood circulation is improved, not only in the injured extremity, but also in the whole body. Respiratory and digestive functions are stimulated and lung complications and constipation avoided. After bony union has taken place, the patient is able to leave his bed at once and walk during the first days by the aid of a cane and after a week, usually unaided.

If the extension frame with the pulleys is not at hand, we can use a V-shaped splint with 3 pulleys. This, however, possesses quite a disadvantage, because it does not allow an abduction effect and can therefore not be used in fractures of the upper end of the femur.

Fig. 145 shows a form of an extension splint with three pulleys, one for the thigh, one for the leg and one for the foot, firmly attached to the body of the splint. This splint can be abducted to any extent desired. If there are any rotations to be corrected, we can attach a U-shaped iron piece over the knee as shown in Fig. 132 and fasten the outer end of the nail in this corrected position.

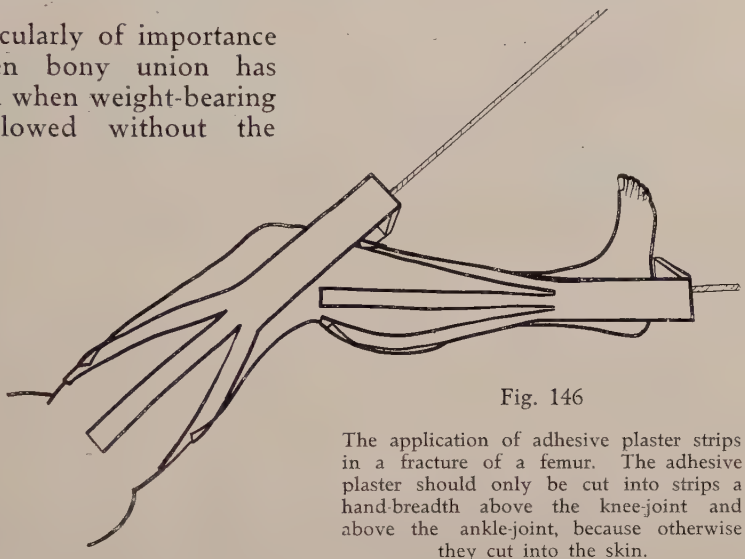


Fig. 146

The application of adhesive plaster strips in a fracture of a femur. The adhesive plaster should only be cut into strips a hand-breadth above the knee-joint and above the ankle-joint, because otherwise they cut into the skin.

It is particularly of importance to know when bony union has taken place and when weight-bearing should be allowed without the danger of new displacements or bendings. Weight-bearing should be started after three months in fractures through the trochanteric region, and in those through the neck where it penetrates deeply into the spongiosa of the trochanters, after four months. Sub-trochanteric fractures need from eight to ten weeks and those in the shaft from seven to eight weeks for solid union to take place, while those near the knee-joint can stand weight-bearing after five to six weeks. This, however, is not a hard and fast rule since occasionally fractures of the shaft and those near the knee-joint require from three to four months for solid union to take place. Healing is much faster in younger than in older individuals. Weight-bearing should only be resorted to, if the patient is able to raise his extremity freely from the bed, and if there is no pain on pressure over the fracture. If after a few days, there is pain over the fracture and also swelling, it indicates that the callus is still soft. In such a case, a new extension dressing must be applied. It takes a few months before the patient is able to resume his work, this varying also with the age and the nature of his occupation.

The Plaster Cast

On account of the extraordinarily powerful muscles about the thigh, fractures of the femur always tend to produce a shortening. The extension dressing is the best method to prevent such a deformity. If for some reason, the use of an extension dressing is not possible, we must occasionally resort to the plaster cast. The latter is the best method of treatment in medial fractures of the neck, if one wishes to secure bony union. The following items are needed for the application of a plaster cast:

(1) 10 to 12 plaster bandages 20 cm. × 5 m. and 6 to 8 plaster bandages 15 cm. × 5 m.
(2) A padding for the sacrum and spine made from cotton or sheet wadding 30 × 10 cm. which after compression should be one finger-breadth thick. 2 pads 8 × 12 cm. for the anterior-superior spines and the crests of the ilium. 1 roll of cotton 35 cm. long and as thick as a thumb, covered by gauze bandage 15 × 120 cm.; this pad is used for the ischial tuberosity and the region of the adductors (Fig. 40).
(3) A gauze bandage 15 cm. × 10 m.
(4) A pelvic support (Fig. 40).
(5) Small box supports for the chest and for the head (Fig. 40). In place of these we may also use correspondingly large pads.
(6) 5 assistants are needed; 2 to hold the extremities, 2 for the application of the cast and the preparation of the plaster splints and 1 assistant to smooth out the plasters (Figs. 148–153).

First, the fracture is rendered free from pain by the injection of a 2% novocaine solution; by this means, the muscle spasm is also excluded. The patient is placed on the pelvic support and the shortening reduced by a slow but powerful pull, avoiding any jerks (Fig. 148). Each ankle is grasped by an assistant and pulled; the feet are placed on two small tables in order that the extremities should maintain the same height and to avoid any undue fatigue on the part of the assistants. If only the fractured extremity is pulled, the pelvis assumes an oblique position. In fractures of the neck of the femur, the extremity must be abducted 45 degrees. In these fractures, after the use of a powerful pull with the extremity in abduction, we see that the lateral displacement is reduced and that both fragments are exactly against each other. By slight inward rotation of the extremity the trochanter major abuts against the pelvis and is so prevented from slipping upwards; it can, however, slip upwards if the extremity is rotated outwardly. The strong ligaments are also a factor in preventing the displacement of the fragments. In fractures through the trochanteric region, the extent of the abduction used is 30 to 40°; in fractures below the middle, both extremities should be placed about parallel to each other. The four pads which have been previously prepared, are now placed in their proper position

Fig. 148

A patient with a medial fracture of the neck of the femur is placed on the pelvic support. An even pull is exerted on both limbs in extreme abduction by two assistants. Each extremity is placed on a table, in order that they be always maintained at the same height and in order to prevent an undue fatigue on the part of the assistants.

Fig. 149

A long pad is applied for the protection of the sacrum and the spine and two smaller ones for the crests of the ilium. A third assistant draws tightly on the round-shaped pad which is used for the protection of the tuberosity of the ischium and the region of the adductors.

The longer one is placed under the sacrum and the spine, the two smaller ones to cover the anterior-superior spines and the roll of cotton over the ischial tuberosity and over the region of the adductors. Both

Fig. 150
The four pads made of cotton are snugly wrapped around with a calico bandage.

ends of the latter pad are pulled upwards by an assistant. All the pads are now fastened in their places by surrounding them with a gauze bandage 15 cm. wide. Six to twelve plaster bandages 20 cm. wide,

Fig. 151
The plaster of Paris bandage applied to the pelvis.

dependent upon the size of the patient, are now applied beginning from the thorax till the middle of the thigh. One plaster splint about 25 cm. long is applied anteriorly and another posteriorly over the hip-

joint, because the plaster breaks easily in this situation. The cast is well moulded between the trochanters and the crests of the ilium and also under the tuberosity of the ischium. A non-padded posterior

Fig. 152

The plaster of Paris bandage applied to the thigh and the leg.

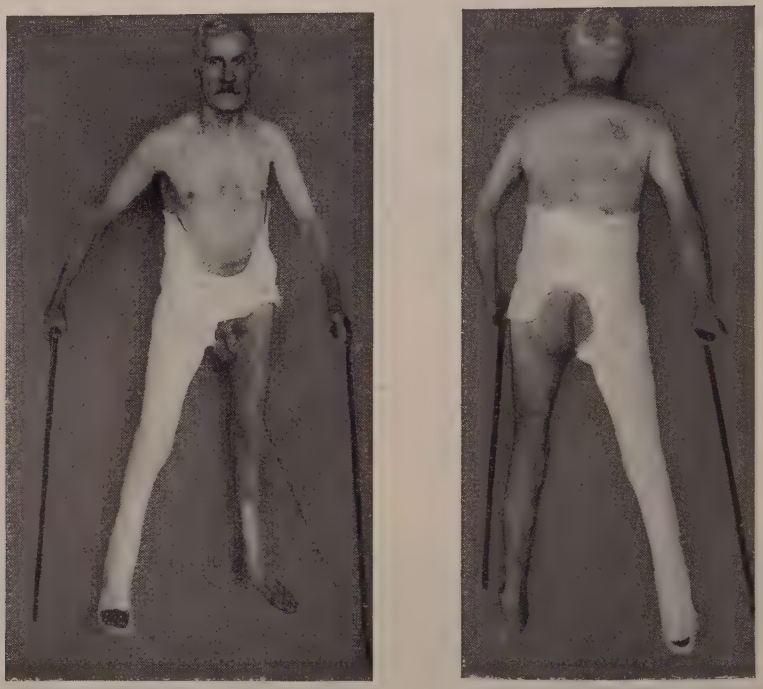
plaster splint is now applied from the ankle to the buttocks and surrounded by three to four circular plaster bandages. Again the cast is well moulded over the condyles of the femur, over the leg and over the patella. Finally, the cast is prolonged to cover the foot, which

Fig. 153

The plaster of Paris bandage applied to the foot. The extensor surfaces of the toes are left free.

should be at a right angle to the leg. For this purpose, one plaster splint and two plaster bandages are used. The cast is applied to the tips of the toes, and only the extensor surfaces of the toes are left uncovered. Sufficient room is provided for the abdomen, as seen in

Fig. 154. The cast in the groin on the normal side, is cut out sufficiently to allow flexion of the hip to a right angle (Figs. 154, 155). In the first two days, we must carefully observe the condition of the toes *so as not to overlook disturbances of the circulation. If disturbances of the circulation take place, the cast must at once be opened in the whole of its longitudinal extent.* If this is not the case, we wait three days and then give the patient the iron walking heel. He can begin



Figs. 154, 155

A plaster cast ready for walking, well moulded anteriorly and posteriorly. It is particularly important to mould the cast between the trochanters and the crest of the ilium so as to prevent the slipping of the femur upwards.

to walk from three to eight days following the application of the heel. At first the patient uses crutches, then a cane and finally he may even walk unassisted. Walking is very difficult in the first week, but later the pains disappear.

The plaster cast is left on six months in medial fractures of the neck, three to four months in fractures through the trochanteric region; in fractures of the shaft seven to eight weeks, and in supracondylar fractures six to eight weeks. After the cast is taken off, a zinc-gelatine dressing is applied from the toes to the knee and the knee bound by an elastic bandage.

Which Treatment should be applied: The Extension Dressing or the Plaster Cast?

In oblique and in splintered fractures, to prevent a shortening or new displacements is impossible on account of the powerful muscles. The continuous weight extension bandage is therefore the method of choice. Because of the fact that fractures above the knee-joint tend to

Fig. 156

A patient with fracture of both femurs due to a fall from the fourth storey; the left side open and the right side closed. Each extremity is placed on a Braun's frame with ten kilogram weights attached to each nail introduced through the tuberosity of the tibia. The foot of the bed is raised 50 cm.

produce stubborn stiffening of the joint and pronounced atrophy of the muscles, this method of treatment is to be preferred. Such fractures should be treated in a hospital because in the absence of well trained nurses, the treatment in a private home by the aid of an extension dressing is not possible. Only in exceptional cases where it is impossible to use weight extension, should we apply the plaster cast in a private home. The result, however, will be questionable. In medial fractures of the neck, the plaster cast is preferred.

In patients with an oncoming delirium tremens or with a frank case of the latter, it is imperative to apply a plaster cast at once.

Exceptional Cases

If several fractured parts are present, it is not necessary to reduce all of them. It is sufficient to bring the upper and the lower fragments in the proper axis. The middle fragments can remain oblique without leading to any disturbances. If there is an adduction of the middle fragment and an abduction of the lower one, the whole extremity is placed in abduction. In order to correct the valgus position of the lower fragment, a U-shaped iron is attached with a screw pressure pad on the medial side.

If both femurs are fractured, 2 Braun's splints and 2 overhead frames are used. Since at least 10 kg. are required for each extremity, the foot of the bed must be raised 50 cm. (Fig. 156).

In oblique fractures above the knee-joint, one often sees a wide gap between the fragments in the sagittal plane. If weight-bearing in these fractures is not started too early, bony union with a good functional result takes place.

A reduction of fractures of the medial or lateral condyles of the femur with displacement or rotation, is often only possible by means of an operation. The exact reduction of these fractures is particularly important in order to prevent a traumatic varus or valgus deformity. The fragment is exposed by a longitudinal incision and fastened by means of one or two rustless nails or by screws. A pelvic cast with an iron walking heel is applied and left on for six to eight weeks. Occasionally we succeed in bringing the fragment into a proper position by means of a nail introduced through the skin.

Errors of Treatment

(1) Incorrect position on soft beds and the use of inadequate splints. Among these we mention especially the double inclined oblique plane on which the leg hangs downwards and therefore becomes swollen.
(2) Insufficient weights, or weights which are only gradually increased. The shortening should not be reduced by a sudden pull, but in the course of a few hours. The full weight should therefore be attached at the beginning.
(3) The extension dressing applied with the knee extended. In this position the knee-joint cannot move and the lateral ligaments become loosened.
(4) The use of too little abduction in high fractures of the femur.
(5) Too short a period of immobilization. On account of this, new shortening and bending take place.

Fractures of the Femur in Children

The most frequent form in children is the longitudinal torsion fracture. The separation of the epiphysis of the upper and lower end of the femur occurs mostly at the time of puberty.

Children under six years old are treated by means of adhesive plaster extension with the knee-joint extended and the leg pointing vertically upwards. Older children are treated with the knee-joint half flexed, same as in adults. In small children, sufficient amount of weight is attached so that the buttock on the injured side floats freely; in older children, about one sixth of the body weight is used for weight extension.

In young individuals, there is no danger of the knee-joint becoming stiff, so that a plaster cast can be applied immediately after the fracture has been accurately reduced. After a few days, the children are able to walk with the cast on. The extension dressing or the plaster cast is left on for four weeks in children under four years of age, while in the older ones, for six weeks.

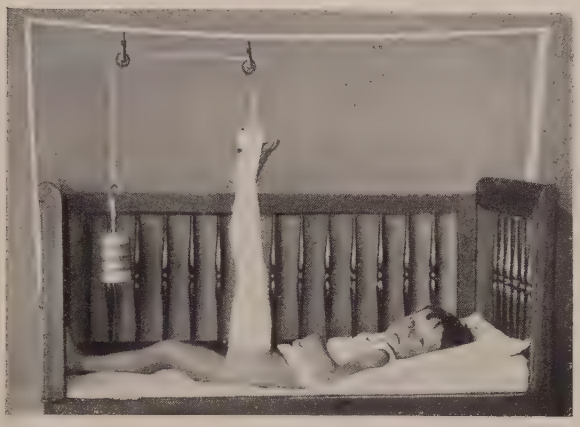


Fig. 147

The treatment of a fracture of the femur in a child. The extremity is suspended in a vertical direction by means of an adhesive plaster dressing. The weights are so arranged that they cannot fall on the child.

The treatment of separation of the epiphysis in the upper end of the femur is described on page 108. The separation of the epiphysis at the lower end of the femur, is treated by the use of the nail and by the same position as in the supracondylar fractures in adults.

If we are not successful, we loosen first the fracture over a wooden wedge (Fig. 171). In recent fractures, where the epiphysis is slipped out anteriorly it is possible to bring it back into its proper position by a strong flexion of the knee-joint. The knee-joint is then brought back into a half flexed position.

If weight extension is used in the treatment of separation of the epiphysis at the lower end of the femur and the extremity placed in an extended position with too little weight used, the lower edge of the upper fragment presses on the blood vessels in the popliteal space and is liable to produce disturbances in the nutrition and even gangrene of the extremity.

Compound Fractures of the Femur

During the Crimean War, of all the fractures of the femur caused by gunshot, 96% died and 4% were amputated. During the World

War, the average fatality was 50%. In my own hospital for fractures at Bozen, during the War, there were 111 cases of compound fractures of the femur. Of these, 13 cases died or 11·7%; 7 cases from exsanguination, 5 from septicaemia and 1 from metastatic empyema. Three cases (2·7%), were amputated, one on account of a concomitant injury and infection of the knee-joint. In the other two cases, there was an extensive defect of the bone as a result of the removal of splinters 15–20 cm. long, which had taken place in the field hospital. The amputation in these two cases was also carried out on account of the destruction of the nerves. According to the statistics published by Spitzy, out of 389 gunshot fractures there were 247 amputations (64·2%). Erlacher, whose material consisted of 900 cases of fractures of the femur, had an average shortening of 5–6 cm. and often over 20 cm. In my own cases, the average shortening was 0·5 cm. and only in two cases was it 4 cm.; 73 cases healed without shortening.

The treatment of compound fractures of the femur, is among the most difficult tasks in surgery, and demands the greatest skill and perseverance on the part of the physician. The first and the most important consideration is to prevent infection. In recent fractures, the wound is excised down to the healthy tissues. Everything which is crushed or contused, as skin, subcutaneous tissues, fascia and muscles are cut away. The soiled bone is also removed by means of a chisel or bone forceps. Local anaesthesia is used in most of the cases. Clean bone splinters should not be removed. The skin is then sutured without drainage. In this way a compound fracture is turned into a closed one and can be treated as such. The bones in a compound fracture should not be sutured because for the carrying out of this procedure, the bones must be freed to a great extent. New blood vessels are also injured and a foreign body is introduced into the depth of the wound. The danger of infection is therefore increased.

If, in spite of the excision of the wound, an infection takes place, or if the patient is admitted with high fever, the fracture must be uninterruptedly immobilized in weight extension after careful reduction. It is treated in the same way as a closed fracture of the femur, with the nail for extension introduced through the tibial tuberosity. The shortening and the displacements disappear as well as the large pus cavities which are formed between the displaced fragments (Figs. 78, 79). The blood vessels and the nerves again assume their normal course, and now we must provide for the proper drainage of the pus. According to the usual rules, the openings for drainage are made in the most dependent part and therefore most often on the posterior surface of the thigh. The femur is nearly entirely surrounded by the extensor muscles. The adductors are inserted in the linea aspera, and of the flexor muscles, only the short head of the biceps is directly in relation with the bone. Collections of pus in the bone should therefore be emptied by providing drainage through the sheaths of the extensors (Fig. 80). The incision

on the lateral aspect is quite simple; on the inner side we must carefully avoid the blood vessels, because if a drainage tube is placed near them haemorrhage from an erosion of a blood vessel is liable to take place with a fatal termination. A short longitudinal incision is made on the lateral surface and a pus pocket sought by palpation above and below, additional incisions being made when necessary. The same procedure is followed on the inner side. Long incisions must be avoided. The operation should be performed only in bed with the pull exerted uninterruptedly. If the extension dressing is removed for the operation, new displacements of the fragments take place. There is danger of injuring the nerves and the blood vessels, which now have an abnormal course, and because of the movement, chills and metastatic infection often take place (Fig. 81). The drainage tube is left in until union takes place and until the sequestra are removed. Splintered fractures are often firmly united in six to eight weeks. Transverse fractures heal slower since both ends often become necrotic. If, on account of an injury, such as a gunshot wound, many bone splinters are thrown out, or if these same splinters are removed during the operation, the healing process often lasts many months until new bone is formed. The weight extension in such cases must be left on for four to eight months. After the fever disappears, the joints can be exercised in the same manner as in closed fractures, in spite of the presence of fistulae. The sequestra should not be removed before the fifth month.

Fractures of the Femur with Mal-Union

Every fracture of the femur which is healed with an axial displacement and with rotation, or with a shortening of more than 3 cm., impedes the functional use of the leg. In the first three months after the injury, it is always possible to reduce the fracture by a closed operation, by breaking the bone over a wooden wedge or by using Schultze's Osteoclast. If the callus is very firm, the bone can be reset only by an open operation. A longitudinal incision is made on the outside of the thigh, the femur laid free sub-periosteally and separated obliquely by means of a chisel. The weight extension is applied to a nail or to tongs introduced over and above the condyles of the femur. Because the muscles are much shrunken, we need 15–20 kg. in order to overcome the shortening. The bed must be raised 50–70 cm. The shortening is usually reduced in several days, after which we need only 10–12 kg., which now can be attached to the nail introduced through the tibial tuberosity. Weights of 15–20 kg., drawing on the knee-joint, produce a loosening of the latter. The weight extension is left on for six to twelve weeks dependent on the seat of the fracture and the firmness of the new callus.

FRACTURES OF THE PATELLA

Closed Fractures of the Patella

If there are only fissures present, it is sufficient to immobilize the knee-joint by means of a non-padded plaster cast for three weeks, after previously removing the blood clot by puncture. The patient can walk with a cast on, after a few days.

The star-shaped fractures, where the fragments are unevenly placed against each other, but without separation, are treated in the following manner. First, the blood clot is removed by means of a puncture and the local anaesthetic injected. The fragments are then strongly pressed against the underlying surface, i.e. against the anterior cartilaginous surface of the femur, thereby bringing them into the proper level. A non-padded posterior plaster splint is now placed from the tips of the toes to the tuberosity of the ischium and is fastened by a gauze bandage. For this splint we need two plaster bandages 5 m. × 15 cm. Five to six plaster bandages, 5 m. × 15 cm., are used to envelop the splint; the extensor surfaces of the toes are left free. An oval window, 10 × 15 cm. in size, is excised over the anterior surface of the knee-joint and covered by two rubber sponges which are firmly bandaged against the window. The sponges are freshly renewed once or twice daily. In this way, it is possible to prevent a new effusion into the knee-joint, which otherwise would raise the patella and produce a new displacement of the fragments. After a week or so, the swelling of the knee-joint disappears and the patient is allowed to walk after an iron heel is applied to the cast. See page 158. If the cast, on account of the rapid atrophy of the quadriceps, becomes too loose, it should be renewed. Altogether the cast is left on for five to six weeks. After two weeks following the injury, the part of the cast covering the foot can be removed.

If the broken fragments are apart from each other, it indicates that the whole extensor aponeurosis about the knee-joint is also torn. In this case, a normal functional activity can only be obtained if the tissues involved in the extensor mechanism are properly sutured. All the previous methods of treatment are insufficient and only of historical interest. The old writers were of the opinion that the "juice" from the bones, i.e. bone marrow, ran into the joint cavity and thereby caused the stiffness. In order to avoid this complication, they used to put their patients with the abdomen facing down. There were numerous suggestions and schemes to bring the fragments together and hold them in close approximation until bony union took place. One of the simplest methods used, consisted in immobilizing the fracture by means of a splint with the knee-joint extended and the hip flexed, thus aiming to produce a relaxation of the quadriceps femoris muscle. The bone fragments did not remain in approximation and a new gap formed in spite of this treatment. New methods were again found, which aimed to bring both

fragments together by using half rings made of leather from above and below, which were fastened together with bandages, screws or springs. The pull was usually too weak and insufficient; if it was increased, it was liable to produce pressure sores of the skin. Malgaigne constructed his clamps, which had two sharp hooks on each side and which were introduced into the upper and lower fragments through the skin. The hooks were approximated towards each other by means of a screw thread. Malgaigne's clamps were soon abandoned because they frequently produced an infection of the knee-joint. Bruns and Ollier introduced metal pegs and screws in both fragments and exerted thus the necessary pull. This procedure, however, met with the same fate as the one suggested by Malgaigne since the danger of infecting the knee-joint was just as great. Volkmann was then making his subcutaneous suture of the extensor tendon and Kocher was using a wire which he introduced subcutaneously around the bone fragments—and therefore through the joint—and tied the wires anteriorly over an iodoform gauze sponge. All these forms of treatment did not, as a rule, lead to the desired result. Bony union of the fragments did not take place because the shreds of the tendons and fascia between the fragments were not removed. Lister was the first who opened the knee-joint in 1877 under aseptic precautions and sutured the patella by using wire. Shortly after, Lister was followed by Trendelenburg, who performed the same operation. In spite of the suture by means of the wire, the patella would break again; this was due either to the fact that the wire tore, or that it cut through the spongiosa. The surgeons therefore emphasized and demanded more and more that the capsule and the tissues concerned in the extensor mechanism be sutured. If one realizes that the patella is only a sesamoid bone, placed in the extensor aponeurosis, one can then very easily understand why the suturing of the patella by means of a thin wire alone is not sufficient to give a bony union; the wire cannot withstand the weight of the body in walking or in jumping, unless the torn tissues of the extensor aponeurosis are also sutured.

Fractures of the patella with separation of the fragments, can be treated successfully only by an open operation. The bony fragments and the extensor aponeurosis are fully exposed and all the shreds of tendons between the fragments are removed. The extensor aponeurosis is then properly sutured.

The aseptic technique must be very exact, because in this operation the largest joint of the body and the easiest to become infected, is opened. Only one who is master of this particular technique and who has a perfectly equipped operating room at his disposal, should undertake this operation. We never operate before the eighth day after the injury and thus give the soft parts an opportunity to recover. If there are blebs or lacerations of the skin, we wait a longer time until the skin becomes completely normal. Immediately after the injury, the knee-joint is punctured and the effusion removed in order to relieve the tension and the pain.

The operation is performed by using either regional or lumbar anaesthesia. The incision is made transversely and corresponds to the space between the fragments; the larger the gap between the fragments, the longer the incision must be. This gives an adequate exposure of the extensor aponeurosis. Curved incisions with the base above or below do not give a sufficient exposure for the lateral tears. After the skin incision, the fragments are at once exposed in the middle, and laterally the uninjured fascia lata is also seen. The fascia is then incised in the direction of the skin incision, and only then can one see the extent of the tear in the vastus medialis and lateralis, which is prolonged sometimes only laterally, and at other times either upwards or downwards. First, the blood clots and the effusion are removed from the knee-joint by means of swabs attached to applicators; then one removes with scissors, the shreds of tendons which hang over the fragments into the joint (Fig. 157). The smaller splinters should be taken out. The raw edges of the fragments must be well exposed in order to see that they are exactly approximated against each other. Strongly constructed hooks are introduced into the upper and lower fragments, and both pulled against each other until there is an exact approximation of the fragments. In order to avoid an irregularity on the cartilaginous under-surface of the patella, one introduces a raspatory. The assistant holds both fragments together by pulling the hooks against each other, and the surgeon sutures the extensor aponeurosis. The joint capsule is sutured by means of fine catgut or silk, and the torn vastus medialis and lateralis by using stronger suture material. The hooks and the raspatory are now removed and the fragments are seen to be approximated against each other, even if they are splintered. The rectus tendon is sutured in front by using four to five strong interrupted sutures.

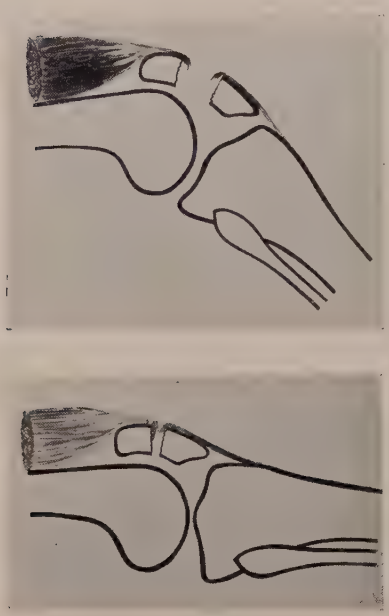


Fig. 157

The torn periosteum and the ragged edges of the torn tendons are found to intervene between the fragments. If they are not removed, the fragments of the patella cannot unite.

The bone fragments are not sutured. The fascia and the skin are sutured separately. If the bone fragments are approximated in the manner described, bony union will always take place.

The knee is immobilized in an extended position and by applying a cast in the manner described on page 134. The sutures are removed after eight days and if the wound is dry, we wait another two days

and the patient is then allowed to walk after the application of the iron heel. The plaster cast is left on for five to six weeks. If it is removed too early, i.e. three weeks after the operation, the fragments are apt to bend against each other.

If the patient is allowed to walk with a cast on, then there is no danger of the joints becoming stiffened or of the quadriceps muscle becoming atrophic, because in walking muscle function takes place. The active raising of the limb surrounded by the cast, strengthens the muscles much more than massage. The patella also slides on its under-surface and therefore does not form adhesions. With the action of the quadriceps muscle the tensors of the capsule also contract and cause the surfaces of the supra-patellar bursa to slide and thus prevent adhesions.

After the cast is removed, a zinc-gelatine dressing is applied from the toes to the knee. During the day, an elastic bandage is applied to the knee above the zinc-gelatine dressing and taken off at bedtime. After exercises on the knee apparatus (Figs. 55, 143) the flexion is gradually increased. By the use of diathermy, hot air and massage, the swelling disappears more quickly. The full active extension of the knee-joint is at once present after the cast is taken off, and after three to four weeks, flexion to a right angle is possible; in older people, a longer time is required. The joint remains swollen, enlarged for two or more months dependent upon the extent and character of the injury.

Compound Fractures of the Patella

If the fracture is an open one with the skin torn, and especially if the wound is dirty, we excise the wound edges clean. We also look for small foreign bodies and all torn tissues and remove them by clean cut excisions. The knee-joint is lavaged with Albrecht's solution or with Rivanol and the skin closed. The torn extensor aponeurosis is not sutured in order to avoid the introduction of foreign bodies into the wound. A non-padded plaster cast is now applied in the same manner as for closed fractures of the patella. After two to four weeks, if the wounds in the skin are healed and completely clean, another operation is performed and the extensor aponeurosis now sutured in the manner previously described.

Old Fractures of the Patella

A pseudarthrosis takes place in all fractures of the patella with a diastasis, if they are not operated on. If the patella itself is sutured and not the extensor aponeurosis as well, it frequently happens that the fragments come apart again and that the wire is torn. We observed one case, in which the silver wire tore for the first time after ten months and for the second time after 16 months. In both of these operations, a curved incision was used with the base pointing downwards. The

flap was too small and neither of the operators could have seen the tear on both sides of the extensor aponeurosis. We made a transverse incision, which encircled the knee for two-thirds of its extent. After exposing the fracture, we found the torn silver wire, which we removed, and discovered the fragments which were apart from each other. The new fracture was found to be lower than the old one. The vastus medialis and lateralis were torn in the whole of their width. Their edges were separated, thickened by scar tissue and covered with synovial membrane; they could not grow together even if approximated. The recessus supra-patellaris was empty. The adhesions were freed, the scars of the edges of the vastus medialis and vastus lateralis were cut away, and the edges of the broken fragments freshened and approximated. The extensor aponeurosis was then sutured in the same manner as described for recent fractures. If the fragments are wide apart, the tendon of the rectus muscle is incised in a V-shaped form two fingers' breadth above the patella. The limbs of the V-shaped incision are about 2–3 cm. long. The upper fragment is pulled strongly downward. In this way the V-shaped incision forms a Y and therefore allows the approximation of the fragments which have previously been freshened. The extensor aponeurosis is now sutured in the usual manner and a non-padded plaster cast is applied as described for recent fractures, and left on five to six weeks. Page 134. If, in spite of this procedure, it is not possible to bring the fragments together, the sartorius muscle can be transplanted and placed over both fragments as advised by Schanz.

FRACTURES OF THE LEG

Fractures of the Intercondyloid Eminence

An X-Ray picture is first taken to determine the character of the fracture. A large calibre needle is introduced into the knee-joint and the haematoma removed. In this way the painful tension is eliminated. 20 cc. of a 2% novocaine solution is injected into the joint. An attempt is now made to extend the joint completely. Occasionally it is possible through this manœuvre to bring the fragment into its normal position. If the reduction is successful, a plaster splint is applied from the tips of the toes to the tuberosity of the ischium. The splint is then surrounded by five or six circular plaster bandages. If, after a week, the knee-joint is no longer swollen, we apply a new plaster cast with the knee-joint extended. The patient is also immediately given a walking iron heel and is allowed to walk. For technique see page 155. The cast is removed six weeks after injury and the zinc-gelatine dressing applied from the toes to the knee. An elastic bandage is also placed over the knee.

If the reduction is not possible by simple extension of the knee, the fragment must be put into its normal position by an open operation.

We wait about a week until the knee is no longer swollen. As a rule, we employ an anterior longitudinal incision on the medial side, unless the anterior cruciate ligament is torn. In this case we make a transverse incision. After the knee-joint is opened and the blood clots removed, we are usually quite surprised not to find the fractured bone, which we could see well in the roentgenogram. The part of the bone can, however, be felt to move if we palpate the tibia. It then comes easily in sight after we incise the synovial membrane. With forcible pressure, by means of an elevator, we can put the fragment in its place. Suturing is not necessary, since the fragment maintains its normal position without any aid.

If the patients appear for treatment weeks or months after the accident, the cavity at the site of the fracture, is filled by callus and the fractured fragment itself is thickened and rounded out. It is no longer possible to bring the fragment into its normal position. In these cases, complete extension is only possible after the fragment is removed. As a result of this operation, the anterior cruciate ligament loses more or less of its attachment. If more than a half of the cruciate ligament is torn away, we reconstruct it. We use a strong silk thread which is passed through the cruciate ligament. Two holes are bored through the anterior side of the tibia and both ends of the thread carried through these holes and tied on the anterior surface of the tibia. The incision is closed after we are sure that the extension of the knee is completely normal. A non-padded plaster cast is applied from the toes to the hip.

If, after eight days, the wound is dry, the sutures are removed and a new plaster cast applied. The patient is thus able to walk ten to twelve days after the operation. Six weeks after the operation, the cast is removed and the patient given a zinc-gelatine dressing and an elastic support for the knee.

If the posterior cruciate ligament is torn and dislocated, we wait a week after the injury and then operate. The knee-joint is exposed by an extensive longitudinal incision posteriorly. We displace the peroneal nerve laterally and the tibial nerve and the blood vessels medially. This approach to the knee-joint is quite difficult and does not allow a good orientation. Here also the broken fragments cannot be seen but only palpated. It is usually impossible to reduce the fragment and it is therefore removed. Before this is done, we introduce a strong silk suture through the posterior cruciate ligament. This is fixed on the posterior edge of the tibia. The time of immobilization is the same as for the anterior cruciate ligament operation.

The knee-joint remains swollen and limited in its motion for several weeks or months, dependent upon the age of the patient and the extent of the injury.

With this form of treatment, we have obtained a good use of the extremity after ten to twelve weeks.

Treatment of Fractures of the Upper End of the Tibia

Fractures of the shaft of the femur and of the leg are treated with a semi-flexed position of the knee-joint. This position should, however, not be employed in the treatment of fractures of the head of the tibia. Every flexion and extension movement of the knee-joint is necessarily combined with an internal and external rotation of the leg against the thigh. If the knee-joint is flexed, any varus or valgus position is difficult to determine in fractures of the head of the tibia. Such fractures should therefore be treated with the knee extended. First, the effusion of blood and serum is removed from the knee-joint and then, if no displacement of the fragments exists, a non-padded walking plaster cast is applied from the toes to the tuberosity of the ischium. With this form of immobilization, the patient is able to walk two or three days after the application of the cast. If considerable swelling of the toes occurs, or if there are any other signs of disturbed circulation or injury to the nerves, the cast must at once be split in its whole longitudinal extent and renewed after five to six days. After six weeks the cast is removed and replaced by the usual zinc-gelatine dressing.

When the fragments of the fractured bone are displaced, and the joint is dislocated—and this applies particularly in cases where the shaft has been driven between the condyles—reduction can only be obtained under powerful traction by means of the screw traction apparatus. It is useless to make any attempts to reduce the fragments by lateral compression as long as the upper end of the shaft of the tibia remains between the condyles; but if one uses powerful longitudinal extension, the splinters which at first glance appear to be chaotically displaced, are laid smoothly against each other. This is brought about by the pressure of the stretched tendons against the fragments. If now some isolated deeply situated fragment still remains out of place, it can be brought into its proper position by introducing a nail through the skin, and controlled under the X-Ray screen.

The following items are needed for this treatment:

(1) A screw traction apparatus (Fig. 38).
(2) Ice tongs, pin or wire (Figs. 56–59).
(3) Eight plaster bandages 5 m. × 15 cm.
(4) One calico or gauze bandage 10 m. × 12 cm.
(5) Clamp and pulleys (Figs. 53, 54).
(6) One strong piece of string 1 m. long.
(7) A small wooden box.
(8) Three 1-kilogram weights.
(9) A narrow scalpel.
(10) Several rustless pins.
(11) A "Redresseur" for the os calcis (Fig. 63).
(12) Local anaesthesia outfit. Page 16 (Fig. 15).

First, a clinical examination is made, paying attention to possible injury to the nerves and blood vessels. 20 cc. of a 2% novocaine solution are injected between the fragments and the patient taken to the X-Ray room for an examination. The anaesthesia, before the X-Ray picture is taken, is important, because the leg can be examined in an extended position. If the picture of the joint is taken in a flexed or slanting position it is apt to give rise to erroneous interpretations.

The effusion of blood and serum is now evacuated from the knee-joint. 5 cc. of a 2% novocaine solution is injected on each side of the heel, or still better two fingers' breadth above the inner and outer malleoli. A puncture is now made to the bone with a small scalpel held perpendicularly and the ice tongs introduced. The small punctured wounds are surrounded with Mastisol and covered with sponges, previously moistened with Balsam of Peru. The patient is now placed on the pelvic support and the ice tongs connected with the screw. The knee-joint is supported by a bandage hung from the iron cross bar in order to avoid posterior displacement of the fragments. The screw is then turned in order to get powerful traction. When the retraction disappears, one presses the deviated condyles strongly together with both hands. If this does not appear sufficient, one makes use of the special "Redresseur" (Fig. 63). The knee-joint must be well padded to protect it against pressure especially on the outside where the peroneal nerve is in danger of being injured. After reduction of the fracture and dislocation, a padded gauze loop is placed over the tuberosity of the ischium and over the adductor muscles, and is pulled upwards by an assistant. A long posterior plaster splint is made, using two standard plaster bandages, and is placed unpadded from the toes to the tuberosity of the ischium and fixed by means of calico or gauze bandages. Four to six circular plaster bandages, dependent upon the size of the patient, are now applied. The dorsal surface of the toes remains free (Fig. 159). If the X-Ray control examination shows that the position is good, the patient is sent back to his bed and three 1-kilogram weights attached to the tongs. The plaster bandage is split in its whole longitudinal extent in order to avoid disturbances of circulation. The wooden box is placed against the sound foot for support (Fig. 160). If, in spite of the longitudinal pull and lateral pressure, one condyle still stands lower than the other, it is lifted by means of a rustless nail through the anaesthetised skin. The opening in the skin, around the nail, is covered by a sponge in the usual manner, and the nail covered with plaster for a period of two to three weeks (Fig. 158). If only one tibial condyle is fractured, the ice tongs and the cast remain only for two or three weeks and the leg, which is no longer swollen, is then placed in a new cast and the patient allowed to walk. If there is considerable displacement, the patient must be kept immobilized and in bed for at least eight weeks. And in case of severe crushing fractures with much displacement and dislocation, the extension must be maintained for four to six weeks

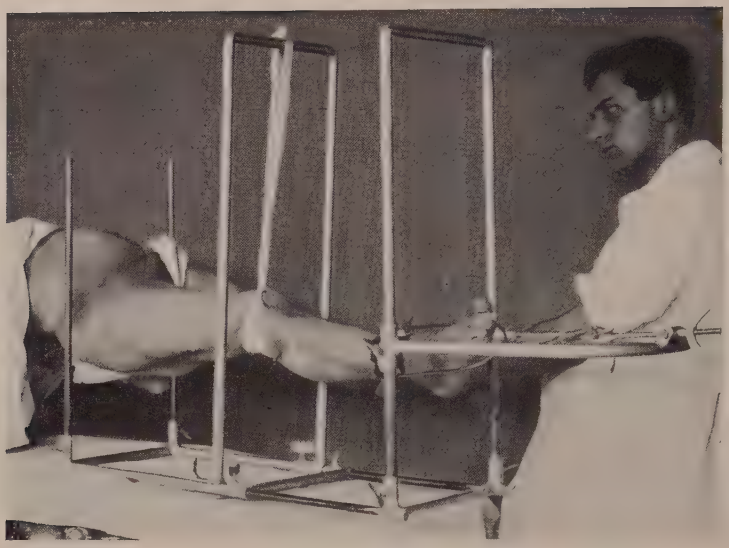


Fig. 158

A reduction and dressing applied to a compression fracture of the upper end of the tibia and fibula with the use of spinal anaesthesia. A longitudinal pull is exerted by the screw attached to the nail which is introduced above the ankle joint. The knee is suspended by a bandage. A nail is introduced into the head of the fibula in order to raise the fragment which has been displaced downwards. An assistant pulls on the normal extremity in order to prevent an oblique position of the pelvis.

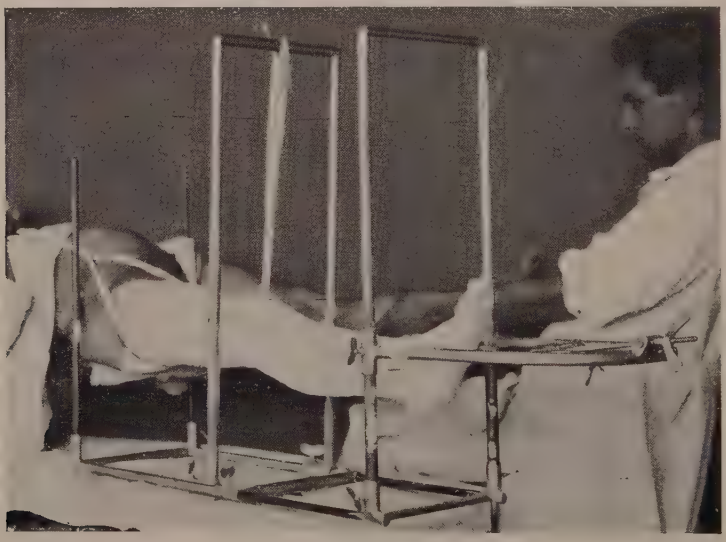


Fig. 159

The plaster cast has been applied. The foot is in a dropped position.

longer. If the extension is removed too soon, and the fragments early subjected to weight-bearing, they are apt to become displaced once more. In severe compression fractures, the immobilization and extension must be maintained for at least ten to fourteen weeks in order to avoid secondary displacements.

When these patients are allowed to walk, the casts should be elongated to include the pelvis. One should pay particular attention to anterior or posterior displacements. After the removal of the cast, a zinc-gelatine dressing is applied from the toes to the knee and the knee encircled by means of an elastic bandage. If the fracture is firm, the patient can now walk without the aid of a plaster cast or a cane as well as he did previously with the cast on. After exercise on the knee bending apparatus (Figs. 55, 142) and after diathermy and hot air treatment, the mobility of the knee-joint is constantly improved. It naturally increases more quickly in young patients and in those cases in which the original displacement was slight and in which the time of immobilization was short. If the mobility remains slight, it is still of great importance to be able to extend the knee completely. A range of mobility between 180° and 150° is far more useful than a mobility of 90° if it lies between 170° and 80°. By means of massage and early movements, the knee-joint can quickly attain a mobility even up to a right angle. If weight-bearing is practised prematurely, the fragments are apt to become displaced and a varus or valgus position with anterior or posterior deviations results. As soon, however, as the axis of the leg is disturbed, a painful arthritis deformans arises which increases year by year and restricts the mobility of the joint as time goes on. If the axis of the whole leg is good, the movements can remain normal in spite of a deviation of the fragments.

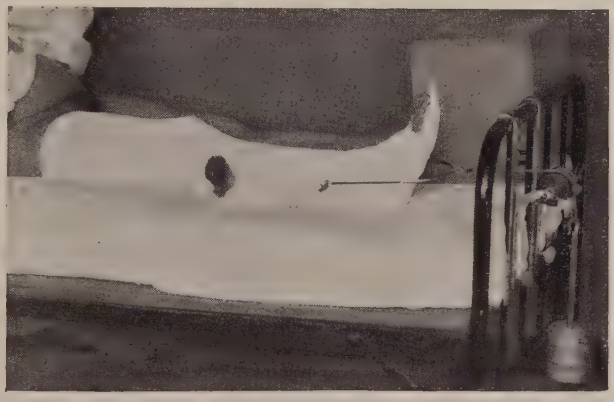


Fig. 160

Position of the patient represented in Figs. 158 and 159 in the ward, with 3 kilogram weights applied for extension. Under the head of the fibula, where the nail has previously been introduced, the bandage is soaked through by blood.

Fractures of the Head of the Fibula due to Rupture

This fracture must be treated by an open operation. The incision begins over the site of the fracture, behind and above, continued downwards and anteriorly. If the peroneal nerve is paralyzed, it is also laid

free. The fractured head is delivered from under the biceps by means of a bone hook and fixed to the shaft by using one or two rustless steel wire sutures. If it is difficult to deliver the fragment, we can try to flex the knee-joint. If the nerve is torn it is sutured in the usual manner. The operation must be performed under the strictest aseptic precautions, because the tibio-fibular joint is often connected with the knee-joint. After the operation, a plaster cast is applied for four to five weeks with the knee-joint extended. After eight to ten days or after the healing of the wound, the patient can begin to walk.

If the peroneal nerve has only been stretched, the function returns after a few months; if it has been torn, the paralysis and the disturbance in the functional ability of the foot remains, in most of the cases, permanent in spite of the nerve suture.

Treatment of Fractures of the Leg

When the shaft of the fibula alone is fractured, we apply a non-padded plaster of Paris cast which, in cases of fractures below the middle, reaches as far as the knee and in fractures above the middle, as far as the thigh. The cast is left on for four weeks.

Fractures of the tibia alone, without displacement and without considerable swelling, can also be treated at once by the application of a plaster of Paris cast which is left on for six weeks. The patients may at once be allowed to walk. When an isolated transverse fracture of the tibia is complicated by displacement to the extent of the whole circumference of the shaft, the reduction is often only successful by an open operation. The fragments are reduced by means of an elevator but not sutured. Only the skin is closed and a plaster of Paris dressing is applied for eight to ten weeks.

All fractures of both bones of the leg showing a displacement of the fragments, can be healed only when the position is corrected and a continuous traction applied. The reduction of the fragments can be reached either by the use of continuous traction or by the immediate action of the screw traction apparatus. For the latter method of reduction we require the following items:

(1) A screw traction apparatus for the immediate reduction (Fig. 37).
(2) A rustless extension clamp (Fig. 58).
(3) A narrow scalpel.
(4) A 10 cc. Record syringe with two long and two short needles.
(5) Two sterile tissue forceps.
(6) One sterile pair of scissors.
(7) Two sterile sponges.
(8) 50 cc. of a 2% novocaine solution.
(9) Mastisol.
(10) Balsam of Peru.
(11) Tincture of iodine.

(12) Nitrate of silver stick.
(13) Four plaster of Paris bandages 5 m. × 15 cm.
(14) One calico or gauze bandage 10 m. × 12 cm.
(15) A splint for the lower extremity (Fig. 46).
(16) Three 1-kilogram weights.
(17) A bed in which boards are introduced between the horsehair mattress above and the steel wire mattress below. Such firm and even support is of great importance for the proper treatment (Fig. 35).
(18) A wooden box 25 × 30 × 40 cm. in size.
(19) Local anaesthesia outfit. Page 16 (Fig. 15).

(This for both bones)

First, the clinical examination is made including investigation of possible injury to the nerves and blood vessels. Antero-posterior and lateral pictures are then taken. If the patient complains of much pain, a 2% novocaine solution is injected between the fragments of the tibia and fibula before he is taken to the X-Ray room. The tongs are then applied to the os calcis. On the external and inner sides of the heel, two finger-breadths behind and below the malleoli, on skin previously moistened with water, two points are made with the stick of silver nitrate. Now we paint the skin with tincture of iodine which makes the silvery white points stand out against the brown colored iodine. Each point through skin, soft parts and periosteum is injected with about 5 cc. of a 2% novocaine solution. The puncture is made perpendicularly until the bone is reached, using a narrow scalpel. The tongs are then applied and pressed in energetically. The knife should be narrow in order to avoid bleeding when the tongs are introduced. The neighborhood of the wounds is painted with Mastisol. Small sponges, previously moistened with Balsam of Peru, are used to cover the small wounds. If the tongs are inserted higher on one or on the other side, we can also exert an adduction or abduction effect together with the longitudinal pull. The clamps should not be applied too near the malleoli, since medially, we are near the nerves, vessels and the tendons of the tibialis posticus, flexor hallucis longus and flexor digitorum longus; on the lateral side, the tendons of the peronei are in danger of being injured. In order to avoid such lesions, the edge of the knife should be directed backward and downward.

As soon as the tongs are applied, the leg is placed in the screw traction apparatus (Fig. 161). On account of the right-angled flexion of the knee-joint, the gastrocnemius is completely relaxed. When the knee-joint is in a flexed position, the tendons of the flexors project more markedly on the medial than on the lateral side. If we should use a transverse piece for the popliteal space, an adduction of the leg or in the case of a fracture, also an adduction of the upper fragment would take place. The lower fragment would take an abducted position giving rise to a valgus deformity. In order to avoid this, the transverse piece

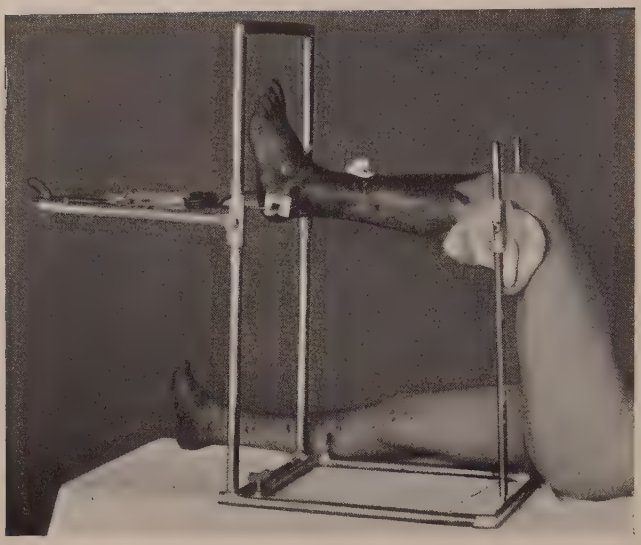


Fig. 161

The leg is placed in the screw traction apparatus and traction exerted through the tongs by turning the screw.

has an angular bend for the medial flexor tendons. This iron support is reversible for the left or right popliteal space (Fig. 39).

At this point, the tongs are connected with the screw of the traction apparatus. By the rotation of the female screw every shortening can be overcome. All other displacements such as rotation or axial kinkings disappear. Laterally deflected fragments usually recede spontaneously after the shortening has been corrected; if not they can be reduced by slight pressure. The drop-foot position also disappears (Fig. 161).

As soon as the fragments are completely reduced, we apply a posterior plaster of Paris splint which is immediately fixed by means of a calico or gauze bandage (Fig. 162). This is now covered by three circular plaster of Paris bandages. For technique see page 155 (Fig. 163). The application of the cast is in this

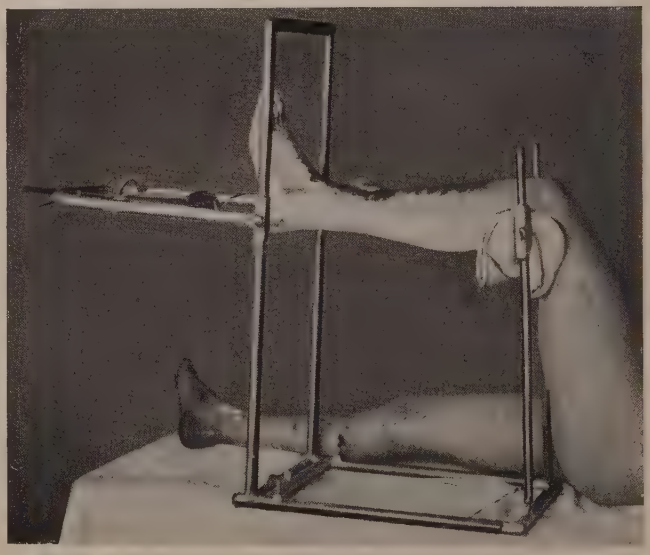


Fig. 162

After the fracture has been completely reduced, a non-padded posterior plaster splint is applied, extending from the tips of the toes and reaching to the popliteal space.

way exceedingly easy; we are not disturbed by the hands of the assistants who are otherwise obliged to hold and pull on the foot.

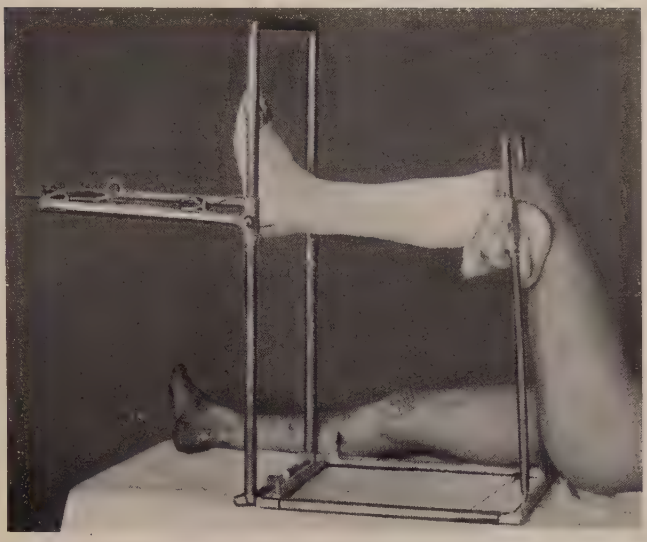


Fig. 163

The posterior plaster of Paris splint is wrapped around snugly with a calico bandage and then with three circular plaster of Paris bandages.

If the X-Ray examination shows that the reduction has been complete, the patient is put to bed, the fractured leg being placed on a leg splint. The little wooden box is used for the support of the normal foot. Three 1-kilogram weights are attached to the tongs and the foot is suspended from the transverse iron bar above the leg splint in order to avoid rotation. The plaster of Paris bandage must then be split in its whole length (Fig. 164). *The splitting of the plaster of Paris cast must never be omitted, because otherwise serious disturbances in the toes and in the*

both bone

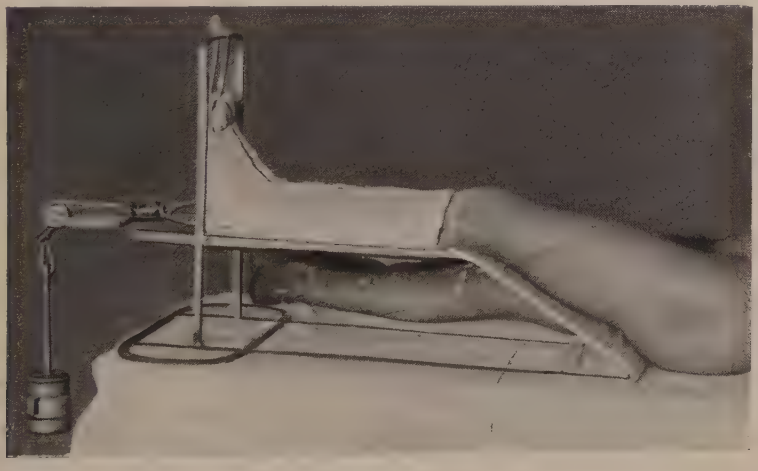


Fig. 164

After the X-Ray control examination, the leg is placed upon the usual leg splint. Three 1-kilogram weights are attached to the ice tongs and the foot suspended from the transverse bar. *The plaster cast is opened throughout its whole length, reaching to the skin.*

whole foot may occur with resulting gangrene. This method of immobilization with longitudinal traction, allows the leg to be kep in good position and supported on every side. Lateral and axial displacements which otherwise recur by the movements of the patient, are no longer possible. It especially renders good service in compound fractures, because the rest necessary for the healing of the wound is never interrupted.

In ordinary fractures this cast remains in its place for three weeks, but in severe compression fractures with much displacement, for five or six weeks. We then apply a plaster of Paris bandage which allows the patient to walk. After the removal of the original cast and of the tongs, we apply, under local anaesthesia, new tongs of suitable length above the ankle-joint or, if the fracture lies near the ankle-joint, again into the os calcis at a distance of about 0·5 cm. from the former place. The leg is again placed in the apparatus (Fig. 161) and with a slight action of the screw a plaster cast similar to the original one, is applied reaching as far as the knee. If the X-Ray examination reveals a good position, the bandage is elongated beyond the knee-joint.

Fig. 165

A fracture of the shaft of the tibia and fibula with a plaster cast reaching up to the middle of the thigh, and with the walking iron heel in place.

First a gauze strip which is folded eight times and which is 4 cm. broad, is laid around the middle of the thigh and fastened with Mastisol. Then a calico or a gauze bandage is wrapped around the knee-joint taking care that the bandage is carefully applied beneath the upper margin of the plaster of Paris cast in order to avoid pressure on the skin by the upper sharp margin of the cast. Then a plaster splint 40 to 50 cm. long, is applied on the posterior surface of the lower extremity with the knee-joint extended; this is fastened by the circular application of three or four of the standard plaster bandages, dependent upon the patient's size (Fig. 165). It is important to continue the application of the bandage as far downward as the middle of the leg, because otherwise it breaks below the knee-joint. After an hour or so, when the plaster has become hard, the walking iron heel can be applied. For technique see page 158. Usually, however, we wait for the next day. With the iron heel and the plaster cast, the patient can begin to walk at once. Younger people walk without a cane after two or three days; older ones usually take a longer time.

This plaster cast remains in ordinary fractures for five weeks and is therefore removed eight weeks after the accident. Transverse fractures

between the middle and the lower thirds take at least ten weeks of fixation and sometimes even fifteen to twenty weeks (see page 22). If the position has been good and the patients have been walking a good deal, there is but little atrophy of the skin, muscles and bones. After the removal of the plaster cast, the ankle-joint can be freely moved at least to one half of its normal range of action. In younger patients, the knee-joint can often be flexed to a right angle at once; in older patients, it sometimes takes two to four weeks before this can be accomplished.

If the patients, in spite of a correct position and in spite of continuous walking are not able to walk after the removal of the plaster cast, it proves that the fracture is not sufficiently healed. The X-Ray picture in such cases usually shows an insufficient callus. In such cases, we must apply a new plaster cast without delay and keep it on for another three to four weeks, repeating the same if necessary, until there is evidence that the fracture is completely able to withstand weight-bearing. After the application of each new plaster cast, a control examination by means of the X-Rays must always be made.

After the final cast is taken off, a zinc-gelatine dressing reaching from toes to knee is applied (for technique see page 160) and over the knee-joint an elastic bandage is wound. Then we begin with exercise on the apparatus which is used for flexing the knee (Figs. 55, 141). During the first days, the knee swells more or less and is often painful. In young individuals, these disturbances promptly disappear after the use of moist compresses and diathermy; in older persons it takes a few weeks. The zinc-gelatine plaster is changed every two to four weeks or when it becomes loose. Younger people have to use it as a rule for two months; older ones or those who have varicose veins, for five or six months. The patients usually follow their occupations during this period. Younger people are capable of heavy work and continuous walking three to four months after the accident; older individuals after four to six months.

If we do not happen to have at our disposal the apparatus with the screw contrivance just described, we can reduce the fracture and treat it by continuous skeletal traction using the usual leg splint. The following articles are required for this purpose:

(1) A firm bed support with wooden boards introduced between the horsehair and the steel wire mattress (Fig. 35).
(2) The usual splint for the leg using a special technique for padding (Fig. 46).
(3) Rustless extension tongs (Figs. 57, 58).
(4) A narrow scalpel.
(5) A strip of adhesive plaster 60 cm. long by 5 cm. broad and a little wooden piece 4 × 6 cm. with an opening in the middle to hold a string (Fig. 94).
(6) A gauze bandage 5 m. × 12 cm.
(7) A strong string 1 m. long.

(8) Five to ten 1-kilogram weights.
(9) A small wooden box 25 × 30 × 40 cm.
(10) A small step or two logs of wood (Fig. 130).
(11) Two small sterile tissue forceps.
(12) One sterile pair of scissors.
(13) Two sterile gauze sponges.
(14) Tincture of iodine.
(15) Mastisol.
(16) Balsam of Peru.

After the clinical and X-Ray examination of the leg is made, the latter is placed upon a properly wrapped leg splint. The wrapping of this splint must begin at the transverse piece of the horizontal portion and be kept equally tight up to the knee. The knee-angle itself must be wrapped very tightly, but below the knee-joint the wrapping is loose in order to allow sufficient room for the protruding calf (Figs. 167, 170). If the leg is allowed to rest on an even support, the muscles of the calf which are markedly swollen after every fracture will press the upper fragment forward, producing a convexity anteriorly. Malgaigne has long known this persistent displacement. In an attempt to overcome this displacement, he invented his screw contrivance (Fig. 166) with the help of which he tried to press the upper fragment downward. As can be readily seen from the illustration, it is quite impossible to bring about a reduction by this method. In the first place, Malgaigne did not overcome the shortening and as long as this persists, we are unable to reduce the lateral displacement. In the second place, the calf rests on an even board and is unable to adapt itself. By a suitable wrapping of the leg splint, however, and by overcoming the shortening by continuous longitudinal traction, the upper fragment falls downwards and the angle between the two fragments, open posteriorly, disappears (Fig. 168).

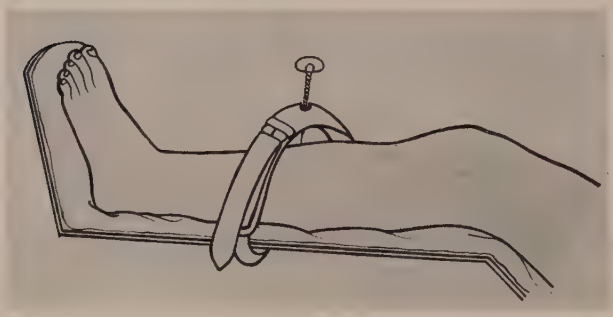


Fig. 166
Malgaigne's pin.

Now the strip of adhesive plaster with the small piece of wood, is applied to the foot previously painted with Mastisol and then tightly wrapped with gauze bandage. The foot is then suspended from the transverse iron bar of the splint. The tongs are applied to the os calcis. For technique see page 145. In transverse fractures, the reduction is attempted at once by pulling on the tongs and if this has been successful,

three 1-kilogram weights are attached to the tongs. In oblique fractures, we need three to ten kilograms dependent on the degree of shortening. The normal foot always finds its support on the little wooden box. The splint of the leg is arranged in such manner that, with the knee-joint of the normal side in extension, that of the fractured side lies directly on the angle of the splint. When a weight of three kilograms is used, the bed is kept in a horizontal position. When the weight is increased to four or more kilograms, the bed is raised 30–50 cm. from the floor (Fig.130). When the shortening is reduced, which usually happens a day or two after, we may reduce the weight to three kilograms and bring back the bed to its usual position. In old fractures, the increased weights must be retained for two or three weeks. In most cases we bring about by means of the longitudinal traction, not only the reduction of the shortening, but also of the axial displacement in the frontal plane and, in addition, of the varus and valgus deformities. In rare cases, if lateral displacement should still persist, we apply lateral traction with a weight of one half to one kilogram as depicted in Fig. 170. Also by means of the foot traction we are able to correct all the rotations,

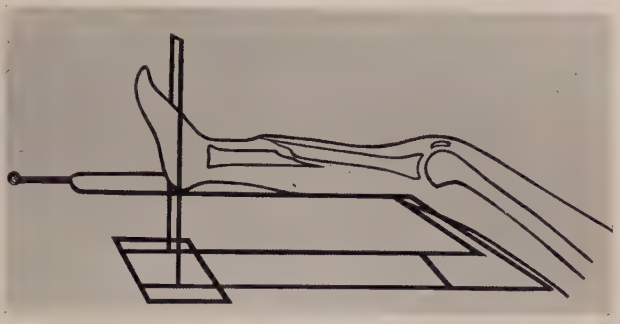


Fig. 167

A wrong position of a fractured leg with no padding in the popliteal space and with an even firm support under the calf. In this way, the knee sinks down, the upper fragment is pushed forward by the muscles of the calf and may pinch the skin. Circulation is also disturbed. On account of the absence of a pad under the tendo Achillis, of the tongs pulling on the heel and of the suspension of the foot, the lower extremity is open to all sorts of dangers. The heel is pressed upon the splint, the foot sinks in a drop-foot position and the lower fragment may turn outwards.

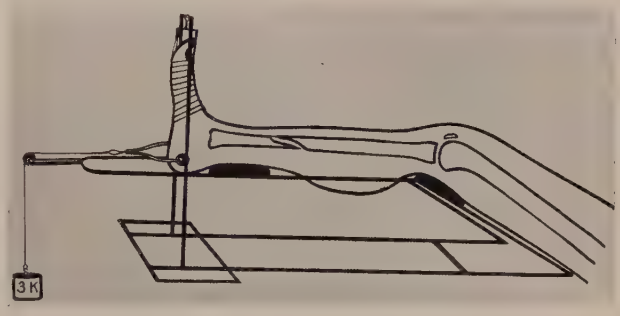


Fig. 168

Correct position of a fractured leg with tongs extension and with a pad in the popliteal space; the bandaging is loose under the calf; there is a pad under the tendo Achillis and the foot is suspended from the transverse iron bar. The pad in the popliteal space and the loose bandaging under the calf, allows the proximal bone fragment, which is directed forward, to assume a normal position as soon as the shortening disappears after the application of the longitudinal traction. The pad introduced under the tendo Achillis and the suspension of the foot prevent pressure sores on the heel, drop-foot and rotation of the lower fragment.

prevent drop-foot and bed sores of the heel; by raising the foot higher or lowering it, we are, in addition, able to correct anterior or posterior displacements.

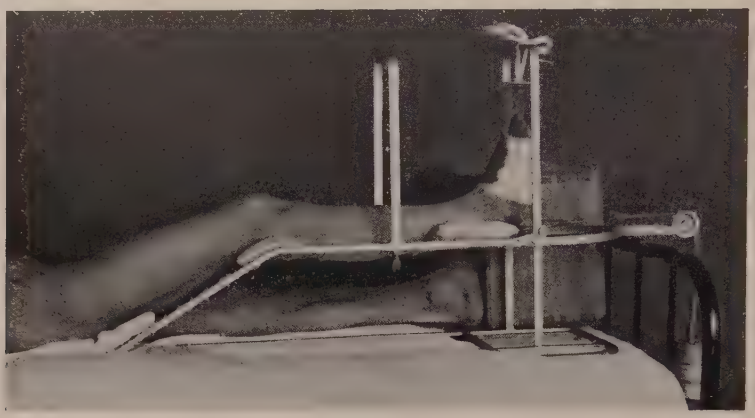


Fig. 169

Fracture of the leg resting upon a correctly wrapped leg splint with the ice tongs in the heel. Three 1-kilogram weights are attached. A U-shaped iron bar serves as protection against pressure from the blankets. A pad is placed under the heel and in the popliteal space. A small box to serve as support for the normal foot. Wooden boards under the hair mattress.

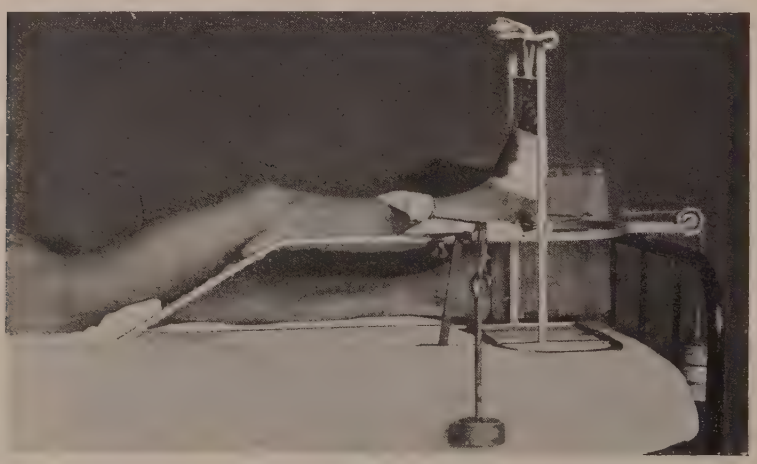


Fig. 170

A fracture of the leg with the application of lateral traction.

If the leg is short and at the same time the foot is suspended from the iron cross bar of the splint, a drop-foot might result. In order to avoid the possibility of such deformity, a movable iron bar is used from which the foot can be suspended in a normal position

(Fig. 204). A similar U-shaped iron is also attached to the splint to protect the leg against pressure from the blankets. If one uses pads on one or the other side of the leg, between the leg and the iron bars, one is able to correct lateral displacements in the same manner as is used in the treatment of such deformities in fractures of the thigh (Fig. 132). In recent cases, this lateral pressure is to be preferred to the lateral traction because the latter produces disturbances of the circulation.

We prefer skeletal traction by means of tongs introduced into the os calcis, since this method does not disturb circulation. We therefore reject traction by means of adhesive plaster, by the clamps of Hackenbruch or the loop of Rückert which are applied on the ankle-joint. Especially with the latter methods is it possible to find deep ulcers due to pressure, extending as far as the tendons occasionally. Where the tongs, directly applied to the heel, are used as traction, the whole leg remains constantly visible to the eye and we can always easily detect disturbances of nutrition or displacements.

We have treated more than one thousand fractures of the leg by the method just described and only rarely encountered a slight secretion in the wounds where the tongs were introduced, even though some of the tongs remained six months in cases of infected gunshot fractures. In the ordinary fractures of the leg, extension is left on for three weeks but in severe compression fractures for six weeks. We then give the patient a plaster of Paris cast and allow him to walk. The cast must reach from the tips of the toes to the knee-joint, and if the X-Ray control examination shows a proper position, the cast is elongated as far as the middle of the thigh. For technique and after-treatment see page 148.

Fractures of the Leg in Children and in Juveniles

In most of these cases we also use local anaesthesia for the reduction. In fractures of the shaft, the angular and rotation deformities are easily reduced. In separation of the epiphysis of the lower end of the tibia with the accompanying wedge fracture of the adjoining metaphysis and with axial deformity, one is mostly able to reduce only in the following manner: The extremity with the fractured part is placed on a wooden wedge and pressed upon using the force of both hands and applying the whole body weight at the same time (Fig. 171). Then the giving way of the fragments is easily felt. A non-padded plaster cast can at once be applied in fractures of the shaft and also in the separation of the epiphysis. The swellings are relatively slight and one does not fear disturbances of circulation. If, however, exceptionally, the toes should become quite swollen, the cast must be split. In fractures of the shaft, the cast is applied until the middle of the thigh, while in the separation of the epiphysis of the lower end of the tibia, only to the knee. After one or two days, most of the children are able to walk without a cane.

In children who are under six, the cast is left on for four weeks, while in those over six, for five to six weeks. If the reduction is correct, usually no after-treatment is necessary. If, however, in rare cases, swelling takes place, it can be treated with a zinc-gelatine dressing as used in adults.

One never sees any disturbances in the growth of bones if the fractures have been correctly reduced.

Fractures of the Ankle-Joint

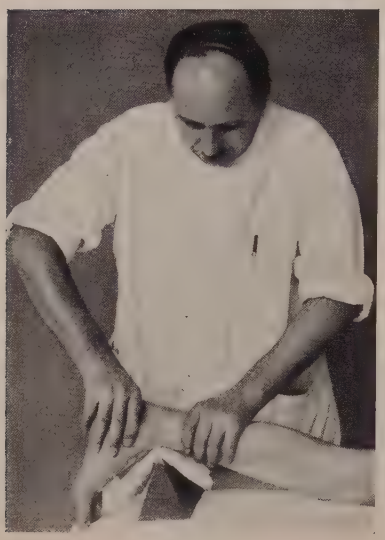


Fig. 171
The reduction of separation of the epiphysis at the lower end of the leg over a wedge.

First we need:
(1) Five plaster bandages 5 m. × 15 cm.
(2) One calico or gauze bandage 10 m. × 12 cm.
(3) One iron walking heel.
(4) Two sterile tissue forceps.
(5) Several sterile swabs.
(6) Tincture of iodine.
(7) Local anaesthesia, page 16 (Fig. 15).

Good frontal and lateral X-Ray pictures are very important for the proper treatment of these cases. The malleoli and the ankle-joint are anaesthetised with a 2% novocaine solution after the previous application of tincture of iodine. If a marked dislocation is present, it is sometimes sufficient to inject into the ankle-joint from the front. The solution then rapidly spreads in the joint and on the fracture surfaces of both malleoli. If the displacement is slight, each malleolus must be anaesthetised separately. If the foot is much swollen, one kneads away the haematoma and the oedema, applying considerable pressure with both hands. One continues to press away the swelling from the dorsum of the foot and especially from the sides of the ankle until the tarsal sinus can be seen and until both malleoli can be outlined and felt quite distinctly. Then the patient sits upon a table with his knee bent at a right angle. The sound foot rests on a chair and the fractured foot on the knee of the operator (Fig. 186). When the patient lets his sound foot hang unsupported, he involuntarily also contracts the muscles of the injured foot. On account of the local anaesthesia, the reflex contraction of the muscles is excluded and by bending the knee-joint at a right angle the gastrocnemius is entirely relaxed.

In case of a dislocation to the lateral side, the leg is grasped with one hand on the inner aspect and above the ankle-joint and with the other hand on the ankle-joint from the outer side. We now apply

strong pressure to the external malleolus and push the ankle-joint and the foot inwards. The pronation and abduction deformities are now reduced (Fig. 189). No over-correction is to be feared, even if the pressure is quite powerful. The heel is in the middle position between pronation and supination and the forefoot in a slight pronation and not in supination. In order to accomplish this, we direct the patient to place the injured foot so that the head of the fifth metatarsal bone rests on the knee of the surgeon. In this manner, the fifth metatarsal is raised and the first metatarsal lowered.

In order to avoid flat foot, most text books advise that one should place the forefoot in strong supination or varus position. Such immobilization, however, will produce flat foot instead of avoiding it, because flat foot is a supination contracture of the forefoot and not a pronation contracture. Therefore we can avoid flat foot only if we pronate the foot with the heel in a mid-position and in such a manner, that when the patient is standing, the heads of the first and fifth metatarsal bones touch the floor. We must not forget, in addition to what has been expounded, that in fractures of the ankle, pronation and abduction take place in the tibio-astragaloid joint, which normally has only the possibility of dorsal and plantar flexion. The movements of rotation in the normal foot, take place in the lower and anterior articulations of the ankle-joint and also in the tarso-astragalo-calcaneous and tarso-metatarsal joints. It is now quite evident that if the forefoot is brought into supination it will be quite impossible with this manœuvre only, to correct the pronation in the upper articulation of the ankle-joint. The lateral displacements of the ankle-joint can disappear only after pressing together the separated malleoli.

As soon as the fracture and subluxation are reduced, a non-padded plaster splint running from the hollow of the knee to the tips of the toes is applied (Fig. 186). The plaster splint is fashioned from a plaster bandage 5 m. long and 15 cm. wide, which is only moderately pressed out and rolled out either on a table or on a glass plate and then smoothed out (Figs. 184, 185). The skin of the leg is neither shaved nor greased. Grease destroys the plaster while the hairs are useful since they become incorporated in the plaster and aid in holding it. Since all the hairs are incorporated in the plaster in a uniform manner, they do not cause any pain. The soft plaster splint, which should be free of folds and wrinkles, is placed against the skin and fixed from the hollow of the knee to the ankle-joint by means of a calico or gauze bandage. An incision into the cast is made on each side of the heel and the two corners thus formed are carefully folded over each other and smoothed out, so that not the least wrinkle remains. The calico bandage which the patient has meanwhile been holding, is wound around the ankle-joint and the foot as far as the toes. On account of the action of the muscles which tend to produce pronation and abduction, even while the bandage is placed, the lateral subluxation as a rule repeats itself; it is therefore

necessary to use powerful pressure against the malleoli in order to correct the displacement and hold it until the plaster splint shows

Fig. 184

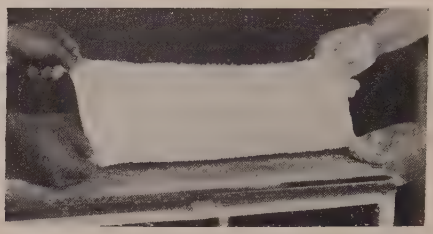


Fig. 185

Fig. 184. Rolling up of a plaster bandage.
Fig. 185. Plaster bandage has been prepared.

evidences of hardening (Fig. 189). Then three circular plaster bandages are applied, leaving the extensor surfaces of the toes free. The circular

Fig. 186

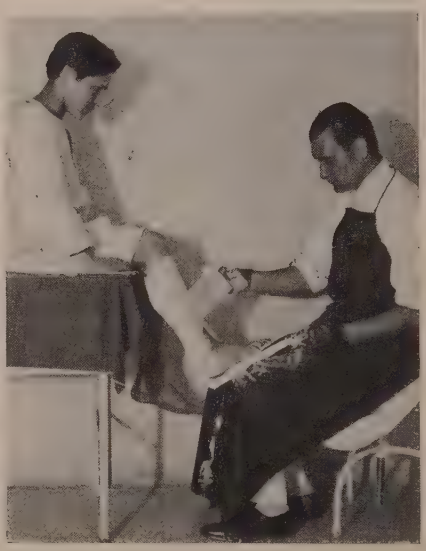


Fig. 187

Fig. 186. The plaster splint, which has been pressed only a little, is being applied. The patient sits on the table with his knee flexed 110°. The foot which is at a right angle is supported by placing the head of the fifth metatarsal bone on the operator's knee. The foot-stool, on which the patient supports his normal foot, is not shown in this picture.
Fig. 187. The plaster splint is fastened to the leg by a calico bandage. An incision is made into the splint on each side of the heel.

plaster bandages are started below the knee-joint and wound around evenly downwards, leaving an interval of two or three finger-breadths between each circle (Fig. 190). The bandage is thus equally strong all

Fig. 188

Fig. 189

Fig. 188. The edges of the splint, which have been incised on each side of the heel, are smoothly folded over.

Fig. 189. The subluxation is reduced by holding the leg above the internal malleolus with one hand and pressing with considerable force with the other hand against the outer malleolus, but not against the heel. In this way, the astragalus is pushed over against the internal malleolus. After the cast is applied, both malleoli are forcibly pressed against each other with one hand somewhat lower on the inner side.

Fig. 190

Fig. 191

Fig. 190. The plaster cast has been applied.

Fig. 191. The walking iron heel is being applied in the axis of the leg.

along its application. After each circular bandage, one presses the malleoli in order to be sure that the lateral subluxation is corrected, since one repeatedly feels that the foot tries to slip lateralwards. One should only stop pressing after the plaster cast has become quite hard. An X-Ray control examination is at once made and if one sees that even the slightest displacement has occurred, the cast is removed, the fracture set again and a new similar bandage applied. This process is repeated as many times as necessary until every displacement has entirely disappeared. If the lateral deviation of the ankle-joint should amount only to 0·5 mm., the joint is no longer congruent and the patient will be subject to continuous trouble on account of arthritis deformans which sets in later.

If no re-displacement of the fragments has occurred, and if the swelling is slight, one can at once apply the iron walking heel and immediately allow the patient to walk. Otherwise, the patient is put to bed with the leg on a Braun's splint until the following day, when a iron walking heel can be applied, provided one is sure that no disturbances of circulation have taken place. In recent fractures of both bones of the leg, we always split the cast immediately, but in the fractures of the ankle-joint, as a rule, the cast is left intact. In contrast to the fractures of both bones of the leg, one rarely observes great swelling in fractures of the ankle, since here the injury is in the bones, tendons and the skin, but not in the muscles. Only in 4% to 5% of ankle fractures do the toes become blue and painful. In such cases, the bandage must at once be opened in order to avoid irreparable injuries to the circulation with its sequelae. It is not necessary to remove the splint entirely since the splitting of the cast provides sufficient space for the blood circulation and at the same time protects against any lateral displacements of the fragments. In those cases in which the bandage must be split, considerable vesicle formation usually occurs. These cases are placed on a Braun's splint with the foot suspended from the iron cross bar in order to prevent rotation. We wait until the swelling subsides, which usually takes eight to ten days. Then a new plaster bandage, together with a iron walking heel, is applied.

The walking heel consists of an iron bar 50 cm. long, 2 cm. wide and 3 mm. thick to which are rivetted at both ends two cross pieces 10 cm. long, 1 cm. wide and 1 mm. thick (Fig. 64). The iron is bent in a U-shaped manner so that the bend protrudes as a heel and the limbs are adapted to the outlines of the malleoli. The two iron cross pieces are bent with a pair of flat pincers so as to fit the circumference of the leg. The iron is applied exactly in the axis of the leg and the distal part projects two finger-breadths beyond the heel of the cast. This is necessary in order to bring the iron walking heel to the level of the boot heel on the sound side. Beginners, as a rule, apply the walking iron incorrectly with an angle open anteriorly between the heel and the leg. On account of this recurvation, the patients feel a tension in the knee-joint and therefore walk with difficulty. The iron walking

heel is fixed over the plaster cast by a plaster bandage, which is especially wound around the cross pieces in order to prevent the slipping of the iron. One circuit of the bandage is also applied at each side of the heel in order to fasten it on both sides (Fig. 192). The walking surface of the iron heel is wound with cotton wool or furnished with a bit of leather or rubber, to prevent the patient from slipping. An iron applied in this fashion is able to withstand the weight of the heaviest man for two to three months. The iron heel is not intended to take away weight-bearing from the fracture; it is used only to protect the plaster bandage.

In ordinary fractures, without luxations, the plaster cast remains on for six weeks, while in those with dislocations, for seven to ten weeks, dependent upon the extent of displacement. If, in the latter cases, the bandage is removed after six weeks, a new valgus position with a subluxation may occur on account of weight-bearing on the still soft callus. We have seen in one case of an ankle fracture with considerable crushing of the outer malleolus, a new displacement which took place after ten weeks of immobilization. In all fractures with subluxations, an X-Ray control examination must be made after 14 days. Should the slightest displacement be noted, the cast must be removed, the ankle re-set and a new plaster bandage applied.

Such a cast affects favorably existing varicose veins, causing chronic ulcers to be reduced in size or to heal.

Most patients can walk without pain and after two or three days, without a cane. The knee and the toes can be actively moved from the beginning. The tibialis anticus and posticus and the peroneus longus and brevis are the only muscles which are not completely used. Despite the fact that the origins and insertions of these muscles cannot approach each other, the muscles contract when the other muscles, which are free, are at work. Such immobilized muscles do not therefore, become atrophied. If the patient walks about during the day, the blood circulation is active in the whole leg and in the muscles which are immobilized. The ability to walk has not only a good effect upon the leg, but also influences the whole body and the mental attitude of the patient. One of the signs that the blood circulation is good, is the disappearance of the swelling in the toes, within a few days, if such existed previously. Individuals who have no hard manual work to perform, such as professional and business men, can resume their duties after a few days. Since the patients can use their legs, disturbances of local nature, such as phlebitis, and of general nature, such as lung or heart complications, which one often sees in bed-ridden patients, are prevented. Such patients do not consider themselves ill, because they have a good appetite, they sleep soundly and they go about freely. After the plaster cast is removed, the ankle-joint can at once be moved and this, in case of old individuals, is at least possible to one half of its normal range of mobility, and in case of patients under 30, often

to the whole of its normal range. The skin is not atrophic or swollen or shining but shows its normal color. The muscles of the calf are hardly weaker than those on the sound side and the bones, according to the X-Ray picture, show very slight atrophy, or none at all. The patients can now walk about freely and without pain. If, however, the patient should still complain of pain after placing the foot on the floor, it is a sign that the healing is not yet absolutely firm. In such cases, a new plaster cast must be applied and kept on a few weeks longer.

Fig. 192

Fig. 193

Fig. 192. The walking iron heel is fixed in its place by a plaster bandage.

Fig. 193. A diagram of the X-Ray film, the date of the injury and the reduction, and also the date when the cast should be taken off are written on the cast.

In all ankle fractures, after the cast is removed and the fracture considered healed, we apply a zinc-gelatine bandage which reaches from the base of the toes to the knee-joint. The zinc-gelatine bandage is renewed every three to six weeks, or when it becomes loose. Young people keep it on for one to two weeks, while older ones and those suffering from varicose veins, up to six months. The following items are necessary for the application of a standard zinc-gelatine bandage:

(1) 200 grams of zinc-gelatine substance. See page 43.
(2) A receptacle holding one liter.
(3) A wide brush (Fig. 71).
(4) A wide-meshed gauze bandage 5 m. × 15 cm.
(5) A wide-meshed gauze bandage 5 m. × 10 cm.

The patient sits on a table with his knee at right angles and with the ankle-joint dorsally flexed to a maximum degree. The foot and the leg are brushed with the zinc-gelatine which has been liquified in a water-bath. Now a piece of gauze 20 cm. long and 15 cm. wide is applied around the heel to the dorsal surface. The foot and ankle-joint are now surrounded with a gauze bandage 10 cm. wide, in such manner that we start first laterally, on the dorsal side of the foot, just at the base of the toes and carry it dorsally to the medial side and under the sole. Such bandaging aims at producing a pronation and

not a supination of the foot. After the third turn, the gauze, still on the lateral edge of the foot, is no longer passed over the surface of the foot, but behind the outer malleolus and around the ankle joint; then from the instep of the foot twice around the heel and then twice more around the ankle until the lower third of the leg. In this way, the forefoot is pronated and the heel supinated, thus establishing an adequate longitudinal arch. The foot is again covered with zinc-gelatine paste,

Fig. 194

Fig. 195

Fig. 194. A non-padded plaster cast compared with one which has been padded; the latter was very heavy and the patient was not able to walk with this cast on.

Fig. 195. A non-padded plaster cast and the part belonging to the walking iron heel taken apart and represented separately.

again applying a piece of gauze to the heel, then wrapping the foot in the manner just described and the whole covered once more with zinc-gelatine paste. Every crease or wrinkle should be avoided. The leg is now covered with the paste and wrapped around with the bandage 15 cm. wide. If the turns of the bandage do not permit of parallel application, no reversed turns are attempted. Instead the bandage is cut and newly applied to preserve uniformity of the bandage. This is carried as far as the knee-joint. Once more the bandage is covered by the zinc-gelatine paste, wrapped with the gauze and a final layer of the paste brushed over it. During the whole procedure the ankle-joint must be flexed dorsally to its maximum. If the dressing is applied with the foot in plantar flexion, folds in front of the ankle-joint, which result later when the ankle is moved, cut their way into the flesh and cause

pain. After fifteen to twenty minutes, the dressing becomes dry but nevertheless is quite soft, so that it does not hamper the movement of the joint. By dabbing it with a 6% formalin-alcohol solution, the dressing dries much more rapidly. In the case of patients who suffer from increased perspiration of the feet, we moisten the dressing in the morning and in the evening. This form of bandage gives the foot a good support and prevents the recurrence of swellings. If the patients, after walking, complain of pain, we subject them to daily treatment by baking over the dressing. No other treatment in the shape of massage or passive movements is necessary, nor suitable. Massage would only be possible after the dressing had been removed. It is true that swellings can be alleviated by massage, but they recur shortly after the patient is on his feet. With the zinc-gelatine bandage, the healing process proceeds far quicker because the foot and the lower leg cannot swell. Younger patients can start work eight to twelve weeks after the injury and older ones, after two to four months.

Every patient with an ankle fracture should be given an arch support to wear. A model is first made with a plaster cast. The patient sits on a table with his knee flexed at a right angle and his foot hanging down. A strong piece of string with a knot at one end is placed between the second and the third toes, running over the dorsal surface of the foot to the leg. A plaster of Paris bandage, which has been folded three times, is laid over the sole of the foot. The rest of the bandage is then wound around the foot and moulded with the heel in slight supination and the forefoot in pronation, thus producing an adequate longitudinal arch. After the plaster has hardened, it is opened on the dorsal surface along the string which has been previously placed. The cast is removed and filled with the liquid plaster mass. This is the negative from which the positive arch support, to fit the individual's foot, is manufactured from hard aluminium, bronze or from celluloid-acetone combined with steel wires, as suggested by Lange and Hohmann.

Fractures of the Ankle-Joint with pronounced Dislocations

In all ankle fractures combined with lateral and posterior dislocations of the foot, the posterior edge of the tibia is broken (Figs. 172–177). The posterior fragment remains in connection with the posterior ligaments. If the knee is flexed at a right angle, the tendo Achillis becomes relaxed. And now, after the lateral displacement has been reduced, we press on the heel and force the foot forward. By a dorsal flexion of the ankle-joint, the astragalus and the os calcis move downwards and pull the posterior fractured part of the tibia into place by the action of the intact ligaments. If the knee-joint be extended, the reduction is impossible because the tendo Achillis is tense (Fig. 223). A non-padded plaster cast is then applied in the manner described on page 155 and left on

for seven to ten weeks, dependent upon the nature and extent of the dislocation.

In the graver cases with posterior dislocation, in addition to the break in the posterior edge of the tibia, a great part of the articular surface of the tibia is also broken off. In these cases, the foot is dislocated so much posteriorly and upwards that the X-Ray picture in the antero-posterior direction does not show the normal joint space any more since the shadows of the tibia and the astragalus are superimposed (Figs. 196–203).

Figs. 172—174

The mechanism of a posterior dislocation of the ankle-joint. As a result of a maximum plantar flexion, a tear results in the anterior ligaments; the astragalus leaps backwards and clips off a part of the lower and posterior edge of the tibia. By means of dorsal flexion, it is possible to bring back the posterior fragment which is still connected with the ligaments.

Figs. 175—177

The mechanism of an anterior dislocation of the ankle-joint. As a result of a maximum dorsal flexion a tear results in the posterior ligaments and the astragalus clips off the anterior lower edge of the tibia. By means of plantar flexion, it is possible to bring back the anterior fragment which is still in connection with the ligaments.

These cases can be reduced in the manner just described but, after the bandage has been applied, the astragalus of the fractured part again slips out posteriorly and upwards. This happens especially if one is obliged to split the cast. Such emergency arises commonly in these fractures since swelling here is frequent. We therefore treat these fractures by means of the traction screw apparatus, in a manner quite similar to the treatment of the fractures of both bones of the leg (Fig. 161). After reduction, the cast is applied while traction is continued, the plaster is split open and the patient kept in bed under traction for at least six

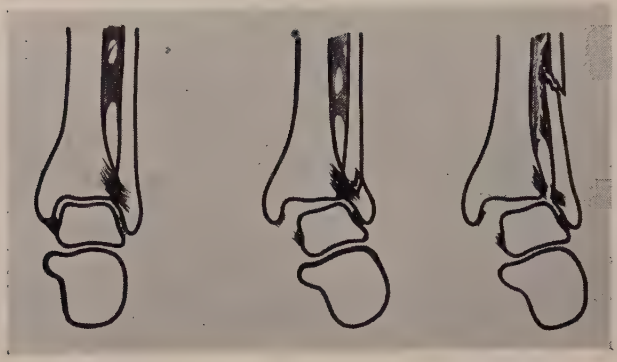


Fig. 178 Fig. 179 Fig. 180

Fig. 178. Frontal section through the upper and lower ankle-joint, including the lower tibio-fibular joint.

Fig. 179. Fracture of the outer malleolus corresponding to the upper limit of the joint, with a tear of the internal lateral ligament, and a dislocation of the foot to the lateral side. The tibio-fibular joint is uninjured.

Fig. 180. Fracture of the fibula a hand-breadth above the ankle, with a tear of the internal lateral ligament and a dislocation of the foot to the lateral side. The tibio-fibular joint and the interosseous ligament are torn apart.

Fig. 181 Fig. 182 Fig. 183

Fig. 181. Fracture of both malleoli corresponding to the level of the joint with a dislocation of the foot to the lateral side. Tibio-fibular joint is intact.

Fig. 182. A fracture of the inner malleolus at the level of the joint. Fracture of the fibula above the ankle-joint from bending, with a dislocation of the foot to the lateral side and a tear between the tibio-fibular joint.

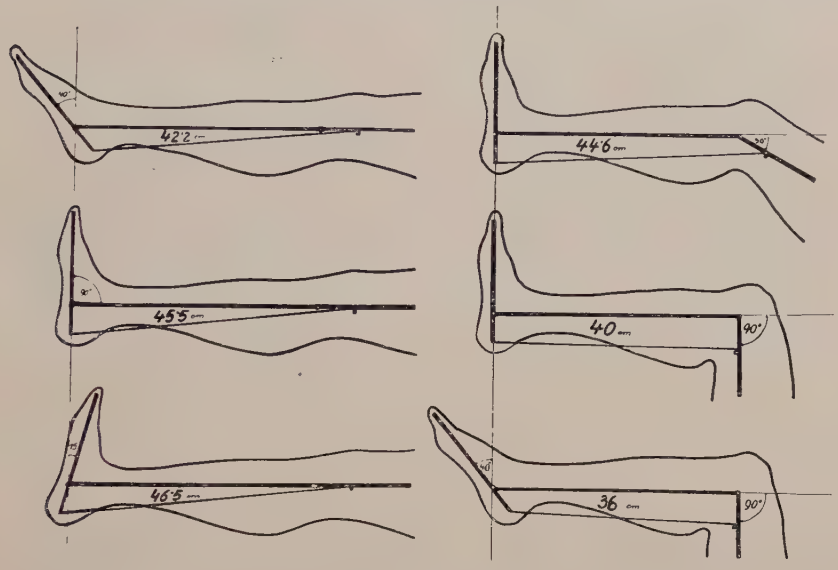
Fig. 183. Fracture of the inner malleolus at the level of the joint and fracture of the fibula a hand-breadth above the ankle-joint. Dislocation of the foot to the outside. A tear of the tibio-fibular joint and of the interosseous ligament.

weeks. This is followed by a non-padded plaster cast which reaches to the middle of the femur and which is well moulded over the condyles of the tibia. In this manner, the full weight of the body is not resting on the fracture. This walking plaster cast remains for another four to six weeks. If the plaster cast is removed too soon, a new posterior displacement of the foot is apt to result. The fracture is otherwise treated with the usual zinc-gelatine bandage.

If the fracture of the ankle presents a supination deformity with a slight varus position, it is treated with a non-padded plaster cast in the manner described for the pronation fractures. The difference, however, is in the method of reduction, since one hand in this case is placed on the ankle above the external malleolus, while the other hand forces the inner malleolus with the astragalus laterally. The difficult supination fractures where the medial third of the lower surface of the tibia is broken, can only be reduced and

kept in good position if we employ the screw traction apparatus. A plaster of Paris cast is applied and split and then three 1-kilogram weights are attached to the tongs and left on for three weeks; then a walking cast reaching to the knee is given to the patient and kept on for five to seven weeks more.

In supination fractures with simultaneous fracture of the anterior third of the tibia and dislocation of the foot anteriorly and upwards,



Figs. 221–226

Fig. 221. With the knee extended and the foot in a maximum plantar flexion, the gastrocnemius is 42·2 cm. long.

Fig. 222. With the knee extended and the foot at a right angle, the gastrocnemius is 45·5 cm. long.

Fig. 223. With the knee-joint extended and the foot in a maximum dorsal flexion, the gastrocnemius is 46·5 cm. long. This is an unfavorable position for the reduction of fractures of the os calcis or of the ankle-joint with a posterior dislocation.

Fig. 224. With the knee-joint flexed 30° and the foot at a right angle, the gastrocnemius is 44·6 cm. long.

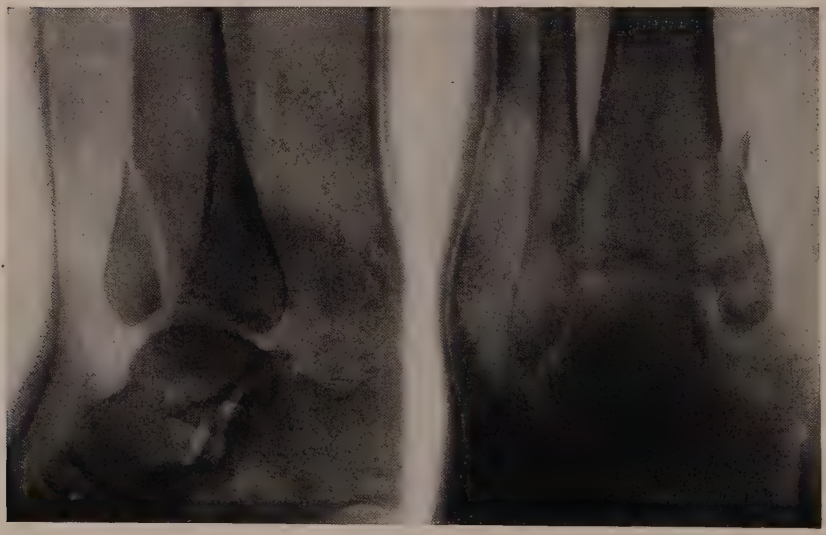
Fig. 225. With the knee-joint and the ankle joint at a right angle, the gastrocnemius is 40 cm. long.

Fig. 226. With the knee-joint at a right angle and the foot in maximum plantar flexion, the gastrocnemius is 36 cm. long. This is the favorable position for the reduction of fractures of the calcaneus, the astragalus, and of the ankle-joint with a posterior dislocation.

the anterior ligaments between the tibia and the ankle-joint remain intact while the posterior are torn. The reduction is possible if we bring the foot into extreme plantar flexion and press on it downward and posteriorly, and at the same time with the other hand, support the leg applying powerful force from behind (Figs. 196–203). Because the posterior ligaments are torn, this fracture always slips forward again; it

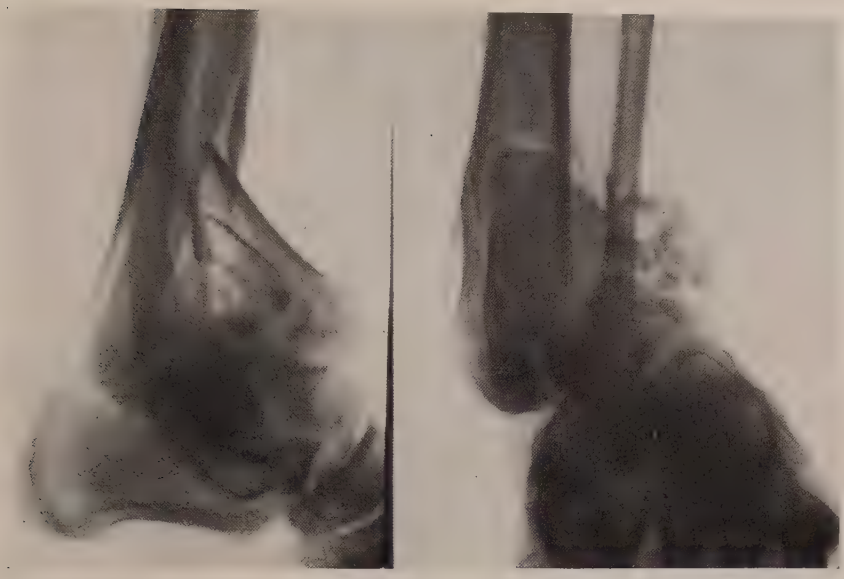
Figs. 196, 197

Fracture of the inner malleolus, due to supination (adduction) with a clipping off of the anterior edge of the tibia and with a subluxation to the inner side and anteriorly before the reduction, resulting from a jump from the third storey.



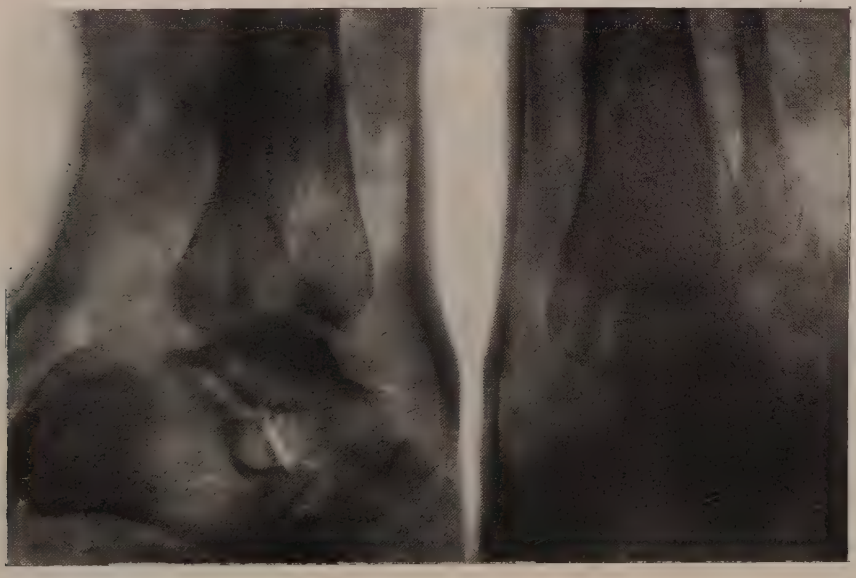
Figs. 198, 199

Roentgenograms of the case represented in Figs. 196 and 197, after the reduction.



Figs. 200, 201

A difficult comminuted fracture at the lower end of the tibia and fibula with a dislocation of the foot laterally and anteriorly, due to a jump from the third storey. (See Figs. 196–199.)



Figs. 202, 203

Roentgenograms of the case represented in Figs. 200 and 201, after the reduction. The moulding of the cast above the heel and the plantar flexion of the foot can be well seen.

is therefore better to reduce it in the screw traction apparatus and treat it with extension and plantar flexion (Figs. 161, 164).

Figs. 196–203 show how even the most difficult and complicated fractures can be kept in a good position. The extension should not be removed before six weeks in these fractures and the walking plaster cast should remain at least six weeks longer.

Treatment of Compound Fractures of the Leg and the Ankle-Joint

Of all compound fractures, those of the leg are the most frequent, because the medial surface of the tibia lies immediately under the skin. In all recent fractures, we excise the edges of the skin and also cut away all torn and soiled tissues, such as the fatty and the subcutaneous layers and the muscles; we chisel away and remove from the bone everything that is soiled, leaving bone splinters which are not soiled in place. We prefer the use of local anaesthesia where it is possible. The skin is accurately approximated by sutures. The bone, the muscles, the fascia and ligaments about the ankle-joint are *not* sutured in order to avoid the introduction of any foreign bodies into the depths. If the defects in the skin are large, we attempt to close them by the aid of other parallel incisions. In this manner, a compound fracture is transformed into a closed one and we can treat it now as such. The screw traction apparatus has given excellent results in this connection. A more exact reduction of the fragments is obtained; the vessels again follow their normal course and the wound is immobilized by a plaster cast in which a window is provided. The attempt to reduce the fracture by the open method using elevators and other instruments, destroys the spongiosa and the marrow and produces fractures where originally there were only fissures; this is also a frequent cause for deep suppuration. The sutured wound remains exposed, without a dressing, and is made accessible by means of a window cut out in the plaster cast (Fig. 204). In this manner, it is possible in most cases to avoid infection with all its possible sequelae, such as osteomyelitis, abscess and sepsis (Figs. 72–75).

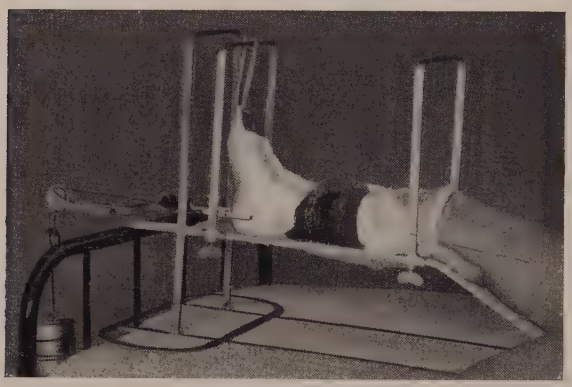


Fig. 204

A compound fracture of the leg reduced and put in a plaster cast by means of the screw traction apparatus. Three kilograms attached to the ice tongs. A window provided for the wound. On account of the leg being too short, the foot is suspended on an extra U-shaped iron frame.

Sometimes the patients run a fever in the first days after the reduction, which may reach 104° Fahrenheit. If the wound, which is carefully watched through the window, remains dry and if surrounding parts or the inguinal glands are not swollen, the sutures are not removed. In most cases, the fever abates in the course of a week.

Fig. 205

A compound infected fracture of the leg incorrectly treated. At the upper end the bandaging has slipped. A window oedema has taken place on the calf of the leg because the necessary hammock support is lacking. A pes equinus resulted because the fore-foot was not suspended. The splint has slid down to the foot of the bed because it has not been fastened by the scissors-like wooden appliance.

If the patients are brought into the hospital with already infected compound fractures of the leg, one should never use the screw traction apparatus for the purpose of reduction, because it is liable to give rise to serious complications. These patients are placed in bed with the leg on the standard splint and only three 1-kilogram weights attached to the tongs. The wound itself is left open. In the hammock of the splint, which is covered by water-proof material, openings are made beneath the leg for the drainage of the secretion. Such openings should not be large because otherwise a local oedema may take place (Figs. 205, 206). As soon as the fever disappears, usually after a few days, the weights can be raised to five or ten kilograms, provided that a shortening still exists. The extension is left on for two to six months, dependent upon the size of the wound and the extent of the comminution of the bone. Bone splinters are not removed because pseudarthrosis might arise.

Fig. 206

A correctly placed compound fracture or the lower leg with a small window under the calf. The foot is suspended and the scissors like appliance is in place.

The wound remains open and is never washed or rinsed. Suppuration is apt to occur less often if the wound is left alone. The crusts which are formed from the wound secretions are removed every two to four weeks.

Compound infected fractures of the ankle-joint, on the other hand, are reduced by means of the screw traction apparatus and covered with a plaster cast in the same manner as fractures of both bones of the leg, with a window provided for the wound. The action of the screw traction apparatus produces a diastasis of the ankle-joint, allowing the pus to drain freely from the joint.

After the wounds are healed or greatly reduced in size, we give the patient a non-padded walking plaster cast and cut a window for the wound. The edges of the window are covered with zinc-oxide ointment. The window itself is carefully filled in by gauze which is firmly compressed. If too little gauze is used, or if the gauze is held insufficiently tight by a bandage, a "window" oedema occurs, cutting the skin around it.

Compound fractures must be kept in fixation until the clinical and the X-Ray examinations show that a firm union has taken place in good position. Sequestra should not be removed before the third month.

Old Fractures of the Leg with Mal-Union

The trouble in the badly healed fractures of the leg, is chiefly due to the displacement of the fragments in the axis and to rotation deformities. The shortening plays a minor part since it rarely exceeds more than 3 cm. When the fragments are laterally displaced and touch each other in the interosseous space, they kink and press upon the blood vessels producing a stubborn swelling. If the fracture is eight weeks old, it is possible to re-set it under lumbar or general anaesthesia. First, the soft callus is broken by bending the leg over a wooden wedge, and then the new fracture is reduced, using the screw traction apparatus. If the fracture is not over five months old and there exists a faulty union with a displacement of the axis, it can be corrected by first using Schultze's Osteoclast and then applying a cast with the aid of the screw traction apparatus. If, on the other hand, in addition to the deformity in the axis, there is also a shortening and a lateral displacement and if the fractures are older than two months, a re-setting is only possible by an open osteotomy. First, we make a sub-periostial exposure of the fibula by a long incision on the lateral side, and the fibula is obliquely divided by means of a chisel. Then the tibia is sub-periostially exposed by means of a longitudinal incision over its medial surface. In torsion fractures, we divide the tibia obliquely in its old fracture line, while in transverse fractures we make a step form effect in order to increase the adaptation surfaces and to open the medullary space more widely. If there is no shortening, the

fragments are joined by the use of two wires around the whole circumference. In case of shortening, the screw traction apparatus is resorted to and the treatment continued in the same manner as in the case of recent fractures of both bones of the leg. See page 145.

In case of old compound and badly healed fractures which are covered by extensive scars adhering to the bone, the osteotomy must be made above or below the old callus at a place which is coverep with normal skin. In ten or twelve days, after the wound has healed, the patients are given a walking cast, provided there is no shortening. Those cases with shortening and where the screw extension apparatus was used, remain three weeks in extension. The walking plaster cast is kept on until the bone is again solid, which may take two to four months.

Fractures of the Ankle-Joint with Faulty Union

Every displacement of the ankle-joint, even the slightest, produces permanent trouble, because the joint surfaces are no longer congruent and are therefore worn out by friction. In the course of time, severe arthritis deformans takes place which becomes more aggravated if the displacement is great. The ankle-joint becomes permanently painful. If there is a pronounced valgus position, flat foot deformity results, while in a varus position a pes cavus is formed.

The supramalleolar wedge osteotomy which has formerly been used so much, can only serve to correct the wrong axis of the leg, but not the dislocation. Normal conditions can only be re-established if the place of fracture is exposed by a longitudinal incision and the dislocation corrected after the bones have been severed with a chisel.

In old fractures with pronation deformity, the old fracture line of the outer malleolus or also of the inner malleolus, if both have been fractured, is separated with a chisel. The skin is carefully closed, the foot is then brought into strong adduction by means of Schultze's Osteoclast and the deformity reduced (Fig. 207). We need the mechanical force and pull as it is impossible to reduce such old fractures with the hands alone. During the mechanical manipulation, the sutures sometimes give way and are therefore replaced. A non-padded plaster cast is now applied in the same manner as for the recent ankle fractures. After ten or twelve days, the patients are given a walking cast which is left on for six to ten weeks, dependent upon the gravity of the case.

In old fractures with a supination deformity, we remove a wedge-shaped piece of bone with its base directed laterally from the outer malleolus. The length of the base of the wedge to be removed, depends upon the extent of the varus position. The inner malleolus is split directly at the level of the joint space or by sagittal incision in the old fracture line. The correction of the varus deformity is much easier than that of the valgus deformity. Usually the foot can be brought in

its normal place with the hand. In the case where the medial surface of the lower part of the tibia has been crushed, it is best to apply plaster cast by means of the screw traction apparatus (Figs. 161, 164).

Fractured malleoli in bad position can be reduced in the first eight weeks without the use of open osteotomy, but rather, by employing the "Redresseur" of Schultze or Lange.

So far we have had no difficulty in older cases not over two years old, in reducing all the fractures and dislocations completely by means of an operation.

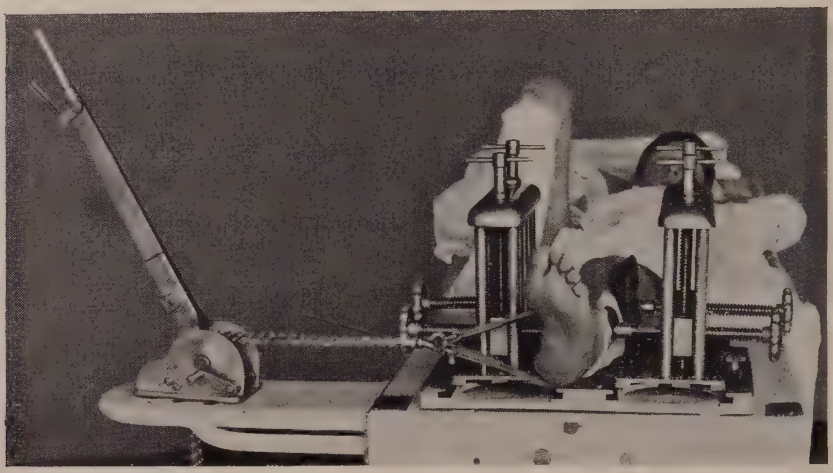


Fig. 207

The reduction of an old fracture of the malleoli by means of Schultze's Redresseur. The leg immediately above the malleoli is held fast by means of the screw pressure pads. The foot, which is displaced outwards, is being slowly brought into its proper place by the lever appliance.

Faults made in the Treatment

Fractures of the head of the tibia should never be treated in flexion, but only in extension. In compression fractures with shortening, we must first overcome this by a longitudinal pull and only then can the deviated condyles be pressed together.

Oblique fractures of the leg or comminuted fractures should, in the beginning, be treated only by traction. When the plaster cast is applied, the foot should never be bent too much dorsally since a convex deformity facing posteriorly in the fracture location might result.

All plaster casts on the flexor surface must reach as far as the tips of the toes since otherwise, especially in infected fractures, bad flexion contracture deformity of the big toe may result. The plaster cast must reach to the knee in ankle fractures, and in the fractures of the shaft, to the middle of the thigh.

The ankle fractures with dislocation can be treated properly only when the cast is not padded. In a plaster which is padded, the force of the muscle pull displaces the outer malleolus laterally, since the soft padding in the cast easily gives way.

The supination of the forefoot does not prevent a traumatic flat foot, but on the contrary, aids in producing it, while the subluxation in the upper ankle-joint persists. Massage and early movements are especially contra-indicated in the ankle fractures, since it produces pain and is only possible when the fixation dressing is removed. This, however, brings about a new subluxation and severe troubles in locomotion.

FRACTURES OF THE ASTRAGALUS

Simple fractures of the astragalus without displacement of the fractured parts, are treated in the same way as simple fractures of the ankle-joint. For technique see page 154. The plaster cast is left on for six weeks. For the after-treatment the zinc-gelatine dressing and the arch supports are used.

If the posterior process of the astragalus is broken, the cast is left on for four weeks.

Fractures of the neck of the astragalus with axial displacement of the bony fragments, forming an angle towards the dorsal surface, are first reduced by a powerful plantar flexion of the foot and then treated in the same way as simple fractures.

The rare fractures of the *astragalus with compression* can be reduced only by the use of the screw traction apparatus with the tongs introduced into the calcaneus, in the manner described in the treatment of fractures of the ankle-joint with pronounced dislocations. We must exert a strong longitudinal pull by means of the screw. For technique see page 145. A plaster of Paris cast is applied and should, as a rule, be split. The extension in the cast (Fig. 164) is left on for three to four weeks, then removed and the patient is given a walking cast. This must be applied so as to reach to the middle of the thigh and be well moulded at the upper end of the tibia so as to relieve the astragalus of weight pressure and avoid a new compression. This form of immobilization is left on for six to seven weeks. All in all, the immobilization is maintained for ten weeks. The after-treatment consists of the usual zinc-gelatine dressing and of arch supports.

Fractures of the astragalus through the neck, are usually characterized by the simultaneous dislocation of the foot anteriorly and medially. The body of the astragalus is flexed maximally to the plantar side. In this way, an angle facing dorsally, is formed between the body and the neck of the astragalus. The body of the astragalus, which has turned

plantarwards on its axis, is hooked by the calcaneus. This displacement can be reduced without an open operation if we employ the screw traction apparatus. After the introduction of the tongs in the os calcis, we apply a strong longitudinal pull with the foot in maximum plantar flexion. The plantar flexion corrects the angle deformity, which faces dorsally, and the strong longitudinal pull frees the fractured astragalus, which is held by the calcaneus (Figs. 208–210). The longitudinal pull produced by the screw, can now be somewhat relaxed and a non-padded plaster cast applied, holding the foot in a maximum drop-foot position. The cast must at once be split open in order to prevent circulatory disturbances. The tongs are removed. After eight days, when the swelling disappears, a new plaster cast is applied and following this, after a few days, the iron heel can be added to the cast and the patient allowed to walk. Three weeks later, the last cast is removed and a new one

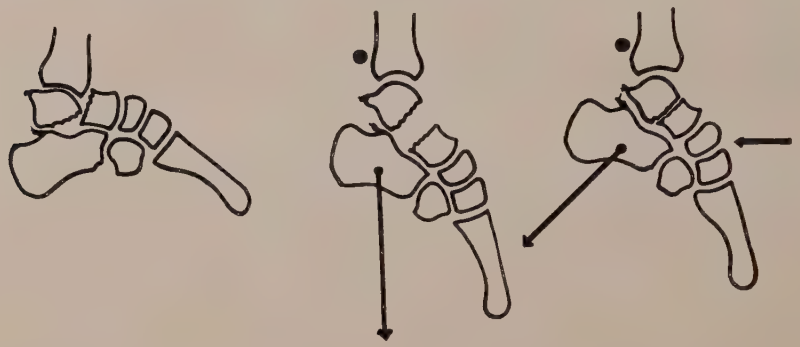


Fig. 208 Fig. 209 Fig. 210

Fig. 208. A fracture of the neck of the astragalus with an anterior dislocation of the foot.

Fig. 209. By exerting a strong longitudinal pull and by plantar flexion, the fragment which has been hooked by the calcaneus is freed and the angular deformity reduced.

Fig. 210. By pulling backwards and downwards with a concomitant forcible plantar flexion, the anteriorly dislocated foot is brought back into its normal position.

applied with the drop-foot position corrected. If the drop-foot position is corrected too early, say a week after the injury, the foot springs into its anterior position again. The new plaster cast should therefore be left on for five weeks. All in all, immobilization should be continued for eight weeks from the time of injury. The after-treatment consists of the zinc-gelatine dressing and of arch supports. The advantage in using the screw traction apparatus for the reduction of these fractures is quite apparent as it eliminates the necessity of injuring and dividing ligaments and other soft parts by open operation. The result and the mobility of the ankle-joint following the conservative treatment, is therefore much better, and the danger of infection is avoided.

FRACTURES OF THE CALCANEUS

In *simple fractures of the calcaneus* without displacement, the haematoma and the swelling are first pressed away, after the injection of a local anaesthetic. A non-padded walking cast is applied and kept on for six weeks. The patient can start to walk at once.

The so-called *duck-bill fractures of the calcaneus* do not result from an upward pull by the insertion of the Achilles tendon because as zur Verth has shown, they are situated above the insertion of the tendon. The posterior end of the bony fragment, which is separated either by a transverse or a longitudinal compression force, is, however, drawn upwards by the tendo Achillis when the foot is dorsi-flexed (Figs. 211, 212). The treatment becomes simple, if we know that the

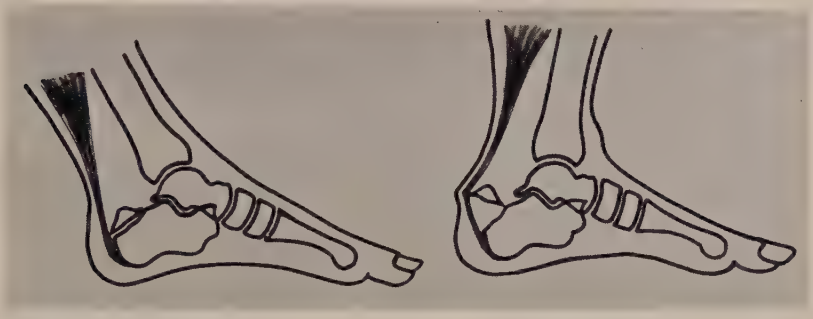


Fig. 211 Fig. 212

Fig. 211. By placing the foot in plantar flexion, the Achilles tendon is seen to pass by the fragment. In this position the fragment can be reduced and maintained in a correct position.
Fig. 212. By placing the foot in dorsal flexion, the Achilles tendon turns the fragment upwards.

displacement is not due to a pull by a torn Achilles tendon, but by the posterior edge of the fragment being caught and drawn up by the intact tendo Achillis. First, 20 cc. of 2% novocaine solution is injected between the fragments. Now by flexing the foot plantarwards to its full extent, the pressure of the tendo Achillis on the posterior edge of the fragment is released. With a little pressure of the fingers, the fragment, which has no connection with muscles or ligaments, is easily placed in its normal position. The haematoma is pressed away by forcible massage and, when the indentations on both sides of the tendo Achillis are again visible, the non-padded plaster splint is applied. The foot must be strongly flexed towards the plantar side and the cast must be moulded about the tendo Achillis above the heel. Three circular plaster bandages are applied in the manner described on page 154. The iron heel can be added on the following day and the patient allowed to walk, provided the toes are not swollen. After three weeks the cast is removed, the drop-foot position carefully corrected and a new cast applied for three weeks with the foot in normal position. An operation is not necessary.

Compressed and Comminuted Fractures of the Calcaneus

A vertical fall from a considerable height causes the astragalus, which is strongly held together by the malleoli, suddenly to strike the calcaneus with its wedge-shaped inferior surface and to break the latter in a longitudinal or transverse direction. The calcaneus becomes wider, often twice its normal width, and at the same time, becomes shortened in its longitudinal extent. Simultaneously there are also axial displacements in the sagittal and horizontal planes with angles open dorsally and medially respectively (Figs. 213–218). Normally the angle between the line extended through the upper joint surface of the calcaneus and the upper surface of the tuberosity is about 27° to 33° (Figs. 219, 220).

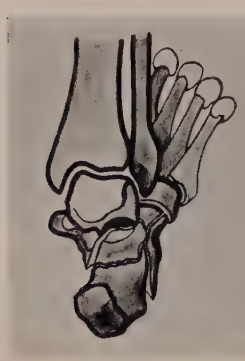


Fig. 213

Fig. 214

Fig. 213. A posterior view of the fractured os calcis. The outer side is fractured, the inner side with the sustentaculum tali, and the posterior joint surface.

Fig. 214. The weight of the body, transmitted through the wedge-shaped astragalus, demolishes the calcaneus lying beneath.

After the fracture, this angle either becomes smaller or disappears altogether, or the tuberosity may even be raised above the joint surface. The axial displacements are produced by the pull of the tendo Achillis and its muscles, and the widening and shortening is maintained by the short muscles of the sole. Both of these groups of muscles exert their pull in a mechanical parallelogram. The sum of these forces can only be overcome, if we apply a pull in the direction opposite to the direction of their forces (Figs. 227, 228). The resultant force is in the axis of the normal calcaneus and by exerting a pull in this direction, we are able to correct both the shortening and the axial displacements, while the widening of the bone can be corrected by adequate lateral pressure from both sides.

The reduction of this fracture is undertaken only after a thorough clinical examination, after lateral, axial and anterior X-Ray films have been made, and after the appearance and the extent of the displacements have been definitely determined.

Fig. 215

Fig. 216

Fig. 215. Comminuted fracture ot the os calcis with a pronounced widening. An axial view. The lateral wall is broken and is bulged out. On the medial side, the sustentaculum tali is displaced. The os calcis is very much shortened.

Fig. 216. A lateral view corresponding to Fig. 215. The astragalus has deeply penetrated into the body of the os calcis. The angle between the upper joint surface and the posterior process has disappeared.

Fig. 217

Fig. 218

Fig. 217. Roentgenogram corresponding to Fig. 215. The os calcis is again normal in its width and in its length.

Fig. 218. Roentgenogram corresponding to Fig. 216. The posterior joint surface between the astragalus and the calcaneus has again assumed its normal width. The angle between the upper joint surface of the calcaneus and the posterior process of the same bone has been restored (it normally amounts to 30°).

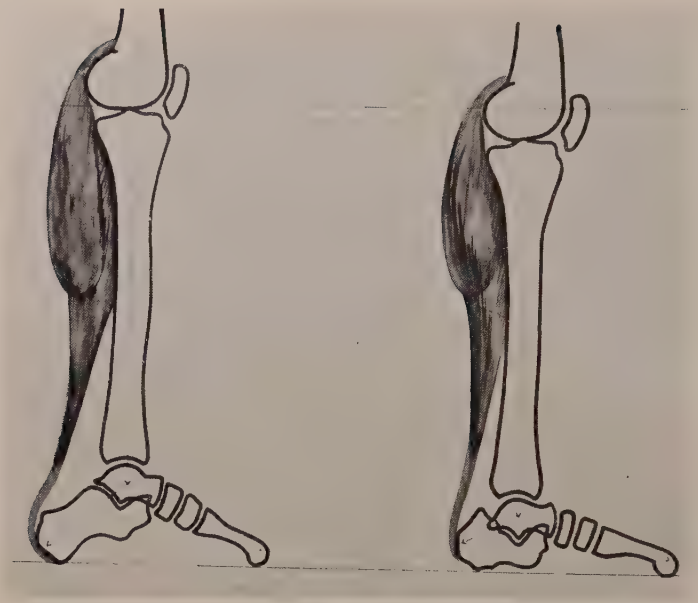


Fig. 219 Fig. 220

Fig. 219. The normal relation between the os calcis and the muscles of the calf.

Fig. 220. After the fracture of the calcaneus, it becomes lower and shorter. Because the arm of the lever at the posterior tubercle of the os calcis and the whole bone is shorter, the calf muscles are relatively longer. The patients are no longer able to walk on the toes or to use the foot in elastic motion.

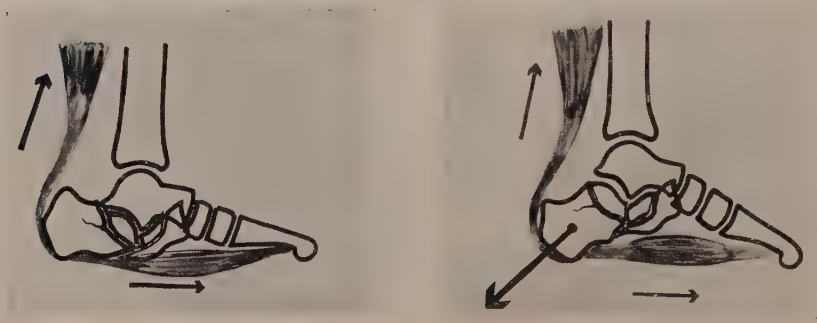


Fig. 227 Fig. 228

Fig. 227. A diagrammatic representation of a fractured calcaneus. The muscles attached to the tendo Achillis pull the posterior fragment upwards and produce an angular deformity; the muscles of the sole pull the same fragment anteriorly and produce a shortening and a widening of the calcaneus.

Fig. 228. The muscles of the calf and of the sole result in a force corresponding to the resultant force of a parallelogram. This force can be overcome by a pull in the opposite direction.

It is advisable to wait four to six days in these fractures of the os calcis until most of the swelling has disappeared.

The following items are necessary:

(1) Screw traction apparatus (Fig. 37).
(2) 2 rustless nails with U-shaped attachments (Fig. 56).
(3) A calcaneus redresseur (Fig. 63).
(4) Splint for the lower extremity (Fig. 46).
(5) 4 plaster bandages 5 m. × 15 cm.
(6) 1 calico or gauze bandage 10 m. × 12 cm.
(7) 4 sterile gauze sponges 4 × 4 cm. split at one side.
(8) Tincture of iodine.
(9) Balsam of Peru.
(10) Mastisol.
(11) Local or spinal anaesthesia outfit, see page 16 (Fig. 15).

First, the seat of the fracture is injected with novocaine or spinal anaesthesia may be used. The haematoma and the swelling are pressed away by the use of vigorous pressure and massage. One rustless nail is introduced through the insertion of the tendo Achillis and another through the soft parts under the tibia and fibula, one hand breadth above the ankle-joint. Each of the nails is then attached to a U-shaped tractor. The leg is placed on the screw traction apparatus with the knee flexed, and suspended from the frame above by the proximal nail. The nail through the tendo Achillis is attached to the screw. Traction is first made in the longitudinal axis of the leg to pull the calcaneus down from its elevated position; the position of the screw is then lowered to bring the traction in line with the axis of the calcaneus. The screw is now revolved until sufficient pull is exerted to overcome the axial displacement and the shortening (Fig. 230). The "redresseur" is now applied on both sides of the calcaneus and the metal appliances pressed together until the calcaneus assumes its normal width. In order to produce a good longitudinal and transverse arch, the foot is slightly flexed plantarwards and the forefoot pronated. A non-padded posterior plaster splint is applied reaching from the hollow of the knee to the tips of the toes and followed by three circular plaster bandages. The dorsal surface of the toes is left free. The plaster is well moulded around the Achilles tendon and on both sides of the calcaneus, where the indentations are left from the pressure of the "redresseur".

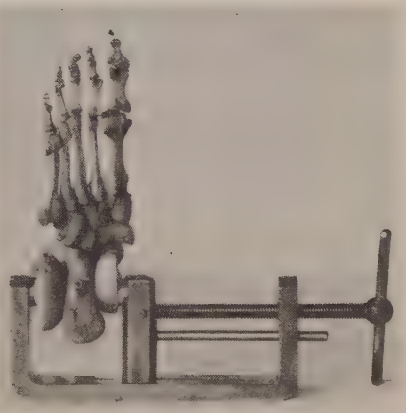


Fig. 229
The os calcis placed in a specially constructed redresseur

After the cast has become sufficiently dry, the screw traction apparatus is removed and the extremity placed on the usual leg splint and three 1-kilogram weights attached to the nail (Fig. 164). If the X-Ray film indicates that the position is good, the nail which was introduced into the leg is removed. Usually no circulatory disturbances take place and the cast is left intact. If, however, the toes should become quite swollen, the cast must be split open at once.

The weight extension with the cast is left on for three to five weeks dependent upon the nature and extent of the comminution. A new walking cast is then applied which is carried from nine to fourteen weeks after the injury. One should not remove the cast too early, because new axial displacements will take place if the callus is still soft.

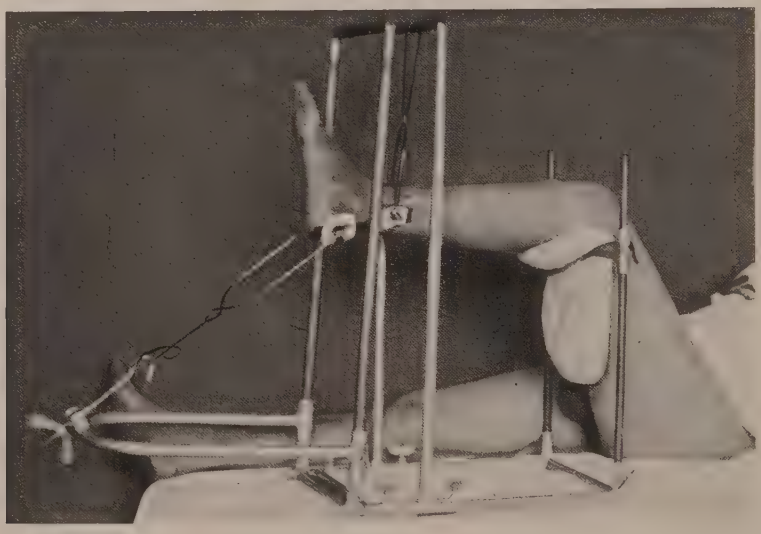


Fig. 230

The screw traction apparatus arranged for the reduction of a fracture of the calcaneus. A nail is introduced under the bones of the leg above the ankle-joint to hold the leg in position. Another nail is introduced through the insertion of the tendo Achillis and exerts its pull in the axis of the os calcis.

The after-treatment consists of the zinc-gelatine dressing and arch supports, which must be particularly strong and have the outer edge raised.

The full use of the foot returns after three to six months, dependent upon the age and the degree of the fracture. If we have succeeded in restoring the normal shape of the comminuted calcaneus, the function of locomotion also becomes normal. Pronation and supination are partially or totally free. The elasticity of the foot in motion is again restored and the patient is once more able to stand and walk on his toes.

FRACTURES OF THE SCAPHOID, CUBOID AND CUNEIFORM BONES

If there is no displacement of the fragments, the seat of the fracture is injected with novocaine solution, the swelling and haematoma pressed away until the tarsal sinus is again to be seen. A non-padded walking cast is applied and left on for six weeks. The patient is allowed to walk soon after. It is particularly important to use a sufficiently long immobilization if the medial edge of the scaphoid is broken away, because otherwise the head of the astragalus would drop through lack of support and aid in the production of flat foot.

The *comminuted fractures of the scaphoid* with dislocation can be reduced successfully only by means of the screw traction apparatus and the reduction can be maintained only if the traction is exerted continuously. The short and long extensors and flexors of the toes, the muscles of the sole, the tibialis anticus and posticus and the peroneus longus and brevis, all pull the forefoot against the astragalus and narrow the interspace where the scaphoid normally lies (Fig. 232).

The following items are necessary for the reduction and immobilization:

(1) The screw traction apparatus used for the arm (Fig. 41).
(2) 2 rustless nails with U-shaped attachments (Fig. 56).
(3) 5 rustless steel wires 1 mm. thick and sharply filed at one end.
(4) 1 hammer (sterilized).
(5) 4 plaster bandages 5 m. × 15 cm.
(6) 1 calico or gauze bandage 10 m. × 12 cm.
(7) A "redresseur" with metal appliances or "pelottes" used for calcaneus fractures (Fig. 63).
(8) 4 sponges 4 × 4 cm., split on one side.
(9) 2 sterilized tissue forceps.
(10) Sterilized scissors.
(11) 1 sterilized needle holder.
(12) Mastisol, tincture of iodine and Balsam of Peru.
(13) Splint for the leg (Fig. 46).
(14) One U-shaped iron band 30 cm. long with wooden arms (Figs. 64, 234).
(15) Local or spinal anaesthesia outfit, see page 16 (Fig. 15).

Fig. 231

The screw traction apparatus for the arm arranged for the reduction of a fracture-dislocation of the scaphoid. One pull is exerted on the nail introduced through the os calcis and a counter-pull is exerted on rustless wires introduced through the tips of the toes. Instead of the latter, one can also use a nail introduced through the bases of the metatarsal bones.

After a satisfactory X-Ray film, the fracture is rendered painless either by local, regional or spinal anaesthesia. If infiltration anaesthesia is used, we must not only inject the solution at the site of the fracture, but also in the calcaneus, the tips of the toes or the bases of the metatarsal bones. A rustless nail is driven through the calcaneus, and through the tip of each toe a sharply edged wire is passed through by means of a needle holder. Each of the wires makes two loops. The loop next to the toes is separated by a small piece of wood so as to keep the wires apart and prevent lateral pressure on the toes. Through the distal loops a wooden rod is introduced, which is attached to the hook of the screw by means of a strong cord. The tractor attached to the

Fig. 232

Fig. 233

Fig. 232. Fracture-dislocation of the scaphoid.

Fig. 233. Roentgenogram corresponding to Fig. 232. The space between the astragalus and the cuneiform bones is widened by exerting a pull in the screw traction apparatus (Fig. 231). The scaphoid is pushed back into place by the use of the same "redresseur" employed in fractures of the os calcis. The comminuted fragments have again assumed their normal position.

nail in the calcaneus, is connected with the opposite end of the screw traction apparatus (Fig. 231).

A strong pull by means of the screw is now exerted and the interspace between the head of the astragalus and the scaphoid is made to widen. It is now usually sufficient by pressure with the fingers or the hand on the dislocated scaphoid, to bring it into its proper place (Fig. 233). During the pressure the crushed splinters unfold again. If the fracture is several days or weeks old, the replacing of the bone is possible only with the aid of the bone redresseur used for fractures of the heel.

After the reduction, a non-padded posterior plaster splint is applied under continued screw traction and fixed by means of a calico bandage; three circular plaster bandages are then wound around the splint to complete the cast. For technique see page 145. When the plaster cast is hardened, the screw traction is removed and the U-shaped iron band

with the wooden arms is fixed to the foot with a plaster bandage (Fig. 234). The free ends of the wires passing through the tips of the toes, are now fixed on the cross piece of this iron band. The extension is left on for six weeks, after which the nail and wires are removed. A new walking plaster cast is applied and kept on for four weeks. The immobilization should not be removed too early, as a new compression of the scaphoid might result.

Instead of using the fine wires introduced through the tips of the toes, one may employ the rustless nail by introducing it either through the bases or proximal to the heads of the metatarsal bones and exerting the pull from these points.

Both of the nails can be incorporated into the plaster cast and the extension removed. A new compression of the scaphoid is no longer possible.

Fig. 234

A dressing employed for the treatment of fractures with displacements of the metatarsal bones and the toes. Rustless wires are introduced through the tips of the toes. A reduction is then accomplished by a longitudinal pull and a non-padded cast applied. The extension wires are attached to a curved iron band fastened to two wooden rods on the sides in order not to disturb the X-Ray film.

CONTUSIONS AND SPRAINS OF THE FOOT

Such injuries cause more or less extensive ruptures of the ligaments with blood effusion under the skin. If the patients are able to walk, a zinc-gelatine dressing is used. If, on the other hand, the walking is very painful, the parts which are injured, are injected with 2% novocaine solution, the haematoma and the swelling pressed away, until the tarsal sinus is again exposed. A walking cast is then applied in the same manner as for the fractures of the ankle-joint. For technique see page 154. The patients are immediately able to walk. The cast is removed two to four weeks after the injury, dependent upon the extent and degree of the injury of the ligaments. For the after-treatment we use the usual zinc-gelatine dressing. If these patients are treated by rest in bed and by the use of moist dressings, or by the application of lead acetate solution, they are sometimes not able to walk for several weeks. The foot remains swollen and painful for a long time, and especially in plethoric women, a thrombophlebitis or other disturbances may take place. On the other hand, if the patient is given a walking cast, he is immediately free from pain and is able to follow his occupation. No long-lasting disturbances take place. After the cast is removed, pro-

vided that the patient has walked diligently, one observes that all the joints move normally, that the skin is also normal and not shining as with oedema.

FRACTURES OF THE METATARSAL BONES

Simple fractures of the metatarsal bones without displacement are treated by a plaster cast. The fracture is first injected with novocaine solution and the haematoma pressed away. The longitudinal and transverse arches of the foot should be well moulded before the cast becomes too hard. In the fracture of the first metatarsal, the cast is left on for six weeks, whereas if any of the other metatarsal bones are fractured, the cast remains only for five weeks. The patients at once begin to walk. After the cast is removed the X-Ray film shows only a slight callus formation. The seat of the fracture is not painful, either to pressure or to weight-bearing. If these cases are treated by massage and baking and are permitted to walk soon after the injury, they do not get along as well. The foot becomes very much swollen and a large callus is formed which is very tender. Walking is hampered for many months or even a year.

Fractures of the metatarsal bones with displacement of the fragments, must be exactly reduced and kept immobilized until solid union takes place. A rustless wire is introduced through the tip of the toe, corresponding to the fractured metatarsal, and a pull exerted in the manner described on page 102. A non-padded cast is applied and particular attention is paid to the moulding of the cast in the longitudinal and transverse arches of the foot. The iron band with the wooden arms is now fastened to the foot over the cast and the wires connected for extension (Fig. 234). The patient is left in bed for two to four weeks, dependent upon the extent of the displacement and the number of the fractured metatarsals. A new cast is applied and well moulded to the foot and the wires removed. The patient is allowed to walk with the cast, which is removed six to seven weeks after its application. A zinc-gelatine dressing and a well fitting arch support is given to the patient.

FRACTURE OF THE SESAMOID BONE OF THE BIG TOE

In these fractures the patient is given a walking cast for four weeks and allowed to walk at once. The after-treatment consists of the zinc-gelatine dressing and of the arch support.

FRACTURES OF THE TOES

Patients with fractured toes, especially the big toe, can walk only with difficulty, since elastic motion of the foot is painful. The dorsum of the foot becomes quite swollen. For these fractures, we also

apply a walking cast, strange as it may seem. In fractures of the big toe, the cast is left on for four to five weeks and for the other toes, for three to four weeks. In this way the patients are able to walk without pain. If the fragments are very much displaced, rustless wires are introduced through the tips of the toes in the manner described on page 102 and left on for one to two weeks. After the plaster is removed, a zinc-gelatine dressing is applied to prevent the swelling of the dorsum of the foot.

In fractures of the big toe, we can also employ a celluloid shell. For technique see page 103.

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